TENTH REPORT

OF

THE MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, APRIL 2, 3, 4, 1908.

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY

WILLIAM S. SAYER,
ACTING SECRETARY

BY AUTHORITY

1908

LETTER OF TRANSMITTAL.

To Hon. Fred M. Warner, *Governor of the State of Michigan:*

Sir—I have the honor to submit herewith the Tenth Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,

William S. Sayer,

Acting Secretary of the Michigan Academy of Science.

East Lansing, Mich., May 28, 1908.

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CONSTITUTION

OF

THE MICHIGAN ACADEMY OF SCIENCE.*

ARTICLE I.

This Society shall be known as "THE MICHIGAN ACADEMY OF SCIENCE."

ARTICLE II: OBJECTS.

The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science.

ARTICLE III: MEMBERSHIP.

The Academy shall be composed of *Resident Members, Corresponding Members, Honorary Members, Patrons* and *Affiliated Societies.*

1. Resident Members shall be persons who are interested in scientific work and resident in the State of Michigan.
2. Corresponding Members shall be persons interested in science, and not resident in the State of Michigan.
3. Honorary Members shall be persons distinguished for their attainments in science, and not resident in the State of Michigan, and shall not exceed twenty-five in number.
4. Patrons shall be persons who have bestowed important favors upon the Academy, as defined in Chapter I, Paragraph 4 of the By-Laws.
5. Resident Members alone shall be entitled to vote and hold office in the Academy.
6. An affiliated society shall be a society accepted by the Council of the Academy, subject to ratification by the Academy at its next regular meeting as having as a principal object the promotion of scientific research in some line or lines, or the diffusion of scientific results in Michigan. Such a Society shall qualify as a member exactly as an individual member and shall exercise its rights of membership through a delegate duly certified by the secretary of said society. Said delegate shall have all the rights of any resident member, except that the publications of the Academy shall be sent to the affiliated society as such as long as the dues of said society are paid and the secretary of the Academy not notified of the selection of a successor, and in case such society contains not less than eight resident members of the Academy such delegate shall ex officio be a member of the Council of the Academy, as

* The history of the Academy will be found in full in the First Annual Report.

hereafter provided. And hereafter in this constitution and by-laws the word "Resident Member" shall be understood to include also said delegates, unless otherwise expressly stated.

ARTICLE IV: Officers.

1. The officers of the Academy shall consist of a President, a Vice President of each section that may be organized, a Secretary and a Treasurer.

These officers and all past presidents shall constitute an Executive Committee, which shall be called the Council.

2. The President shall discharge the usual duties of a presiding officer at all meetings of the Academy, and of the Council. He shall take cognizance of the acts of the Academy and of its officers, delegates of affiliated societies containing a sufficient number of members of the Academy, as provided in Article III, and cause the provisions of the constitution and By-Laws to be faithfully carried into effect. He shall also give an address to the Academy at the closing meeting of the year for which he is elected.

3. The duties of the President in case of his absence or disability shall be assumed by one of the Vice Presidents who shall be designated by the Council.

The Vice Presidents shall be chairmen of their respective sections. They shall encourage and direct research in the special branches of science included within the Sections over which they preside.

4. The Secretary shall keep the records of the proceedings of the Academy and a complete list of the members, with the dates of their election and disconnection with the Academy. He shall also be the Secretary of the Council.

The Secretary shall co-operate with the President in attending to the ordinary affairs of the Society. He shall attend to the preparations, printing and mailing of circulars, blanks and notifications of elections and meetings. He shall superintend other printing ordered by the Academy, or by the President, and shall have charge of its distribution under the direction of the Council.

The Secretary, unless other provision be made, shall also act as *Editor* of the publications of the Academy and as *Librarian* and *Custodian* of property.

5. The Treasurer shall have the custody of all funds of the Academy. He shall keep an account of receipts and disbursements in detail, and this account shall be audited as hereinafter provided.

6. The Academy may elect an *Editor* to supervise all matters connected with the publication of the transactions of the Academy, under the direction of the Council, and to perform the duties of Librarian until such time as the Academy shall make that an independent office.

7. The Council is clothed with executive authority, and with the legislative powers of the Academy in the intervals between the latter's meetings; but no extraordinary act of the Council shall remain in force beyond the next following stated meeting, without ratification by the Academy. The Council shall have control of the publications of the Academy, under the provisions of the By-Laws and of the resolutions from time to time adopted. It shall receive nominations for members, and on approval, shall submit such nominations to the Academy for action. It shall have power to fill vacancies *ad interim*, in any of the offices of the Academy.

8. Terms of Office. The President, Vice Presidents, Secretary, Treasurer and Editor shall be elected annually, and be eligible to re-election without limitation. Delegates shall remain members of the Council as long as qualified, according to Article III.

ARTICLE V: Voting and Elections.

1. *All elections* shall be by ballot. To elect a Resident Member, Corresponding Member, Honorary Member or Patron or impose any special tax shall require the assent of three-fourths of all Resident Members voting.

2. Any member may be expelled by a vote of nine-tenths of all members voting, provided notice that such a movement is contemplated be given at a meeting of the Academy three months previous to such action.

3. Election of Members. Nominations for Resident membership shall be made by two Resident Members, according to a form to be provided by the Council. One of these Resident Members must be personally acquainted with the nominee and his qualifications for membership. The Council shall submit the nominations received by them, if approved, to a vote of the Academy at a regular meeting.

4. Election of Officers. Nominations for office shall be made by the Council as provided in the By-Laws. The nominations shall be submitted to a vote of the Academy at its winter [annual] meeting. The officers thus elected shall enter upon duty at the adjournment of the meeting.

5. At the meeting in which this constitution is adopted the officers for the ensuing year shall be elected in such manner as the academy may determine.

ARTICLE VI: Meetings.

1. The Academy shall hold at least two stated meetings a year—a *Summer* [*or Field*] *Meeting,* and a *Winter* [*or Annual*] *Meeting.* The date and place of each meeting shall be fixed by the Council, and announced by circular at least three months before the meeting. The programme of each meeting shall be determined by the Council, and announced beforehand, in its general features. The details of the daily sessions shall also be arranged by the Council.

2. All members must forward to the Secretary, if possible, before the convening of the Academy, full title of all papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery and a brief abstract of their contents. From the abstracts thus presented, the Council will determine the fitness of the paper for the programme.

3. This section stricken out April 1, 1898.

4. Special Meeting of the Academy may be called by the Council, and must be called upon the written request of twenty Resident Members.

5. Stated Meetings of the Council shall be held coincidently with the stated meetings of the Academy. Special meetings of the Council may be called by the President at such times as he may deem necessary.

6. Quorum. At meetings of the Academy a majority of those registered in attendance shall constitute a quorum. Four members shall constitute a quorum of the council.

ARTICLE VII: Publications.

The publications of the Academy shall be under the immediate control of the Council, but the Council shall accord to each author the right, under proper restrictions, to publish through whatever channel he may choose.

ARTICLE VIII: Sections.

Members not less than eight in number may by special permission of the Academy unite to form a Section for the investigation of any branch of science. Each Section shall bear the name of the science which it represents, thus: The Section of (Agriculture) of the Michigan Academy of Science.

2. Each Section is empowered to perfect its own organization as limited by the Constitution and By-Laws of the Academy.

ARTICLE IX: Amendments.

This Constitution may be amended at any Winter [Annual] meeting by a three-fourths vote of all the Resident Members present.

BY-LAWS.

CHAPTER I: Membership.

1. No person shall be accepted as a Resident Member unless he pay the dues for the year within three months after notification of his election. An affiliated society, after the secretary has been notified that it will be accepted as affiliated shall also be expected to pay the annual dues, but a commutation of twenty-five dollars shall be accepted for a permanent membership. The annual dues shall be one (1) dollar, payable on or before the annual meeting in advance; but a single prepayment of twenty-five (25) dollars shall be accepted as commutation for life.

2. The sums paid in commutation of dues shall be invested, and the interest used for the ordinary purposes of the Academy during the payer's life, but after his death the sum shall be covered into the Research Fund.

3. An arrearage in payment of annual dues shall deprive a Resident Member of the privilege of taking part in the management of the Academy and of receiving the publications of the Academy. An arrearage continuing over two (2) years shall be construed as notification of withdrawal.

4. Any person eligible under Article III of the Constitution may be elected Patron upon the payment of one hundred (100) dollars to the Research Fund of the Academy.

CHAPTER II: Officials.

1. The President shall countersign, if he approves, all duly authorized accounts and orders drawn on the Treasurer for the disbursement of money.

2. The Secretary, until otherwise ordered by the Academy, shall perform the duties of Editor, Librarian and Custodian of the property of the Society.

3. The Academy may elect an Assistant Secretary.

4. The Treasurer shall give bonds, with two good sureties approved by the Council, in the sum of five hundred dollars, for the faithful and honest performance of his duties, and the safe-keeping of the funds of the Academy. He may deposit the funds in bank at his discretion, but shall not invest them without the authority of the Council. His accounts shall be balanced on the first day of the Annual Meeting of each year.

5. The minutes of the proceedings of the Council shall be subject to call by the Academy.

CHAPTER III: Election of Members.

1. Nominations for Resident Membership may be proposed at any time on blanks to be supplied by the Secretary.

2. The *form* for the nomination of Resident Members shall be as follows:

In accordance with his desire, we respectfully nominate for Resident Member of the Michigan Academy of Science.

(Full name)

(Address)

(Occupation)

(Branch of science interested in, work already done, and publications, if any)

(Signed by at least two Resident Members.)

The form when filled is to be transmitted to the Secretary.

3. The Secretary shall bring all nominations before the Council at either the winter [Annual] or summer [Field] meeting of the Academy, and the Council shall signify its approval or disapproval of each. (The Secretary is delegated the power, by general action of the Academy, to accept, subject to the ratification of the Academy at its next meeting, applicants at any time upon the recommendation of two members, as now practiced, and upon the payment of one dollar, which shall cover the annual dues for the year in which it is paid, and that only.)

(Minutes, 1907.)

4. At the same or next stated meeting of the Academy, the Secretary shall present the list of candidates to the Academy for election.

5. Corresponding Members, Honorary Members, and Patrons shall be nominated by the Council, and shall be elected in the same manner as Resident Members.

CHAPTER IV: Election of Officers.

Section 1. At the Annual Meeting the election of officers shall take place and the officers elected shall enter on their duties at the end of the meeting.

Section 2. The Council shall nominate a candidate for each office, but each Section may recommend to the Council a candidate for its Vice President. Additional nominations may be made by any member of the Academy. All elections shall be made by ballot.

CHAPTER V: Financial Methods.

1. No pecuniary obligation shall be contracted without express sanction of the Academy or the Council. But it is to be understood that all ordinary incidental and running expenses have the permanent sanction of the Academy, without special action.

2. The creditor of the Academy must present to the Treasurer a fully *itemized* bill, *certified* by the official ordering it, and *approved* by the President. The Treasurer shall then pay the amount out of any funds not otherwise appropriated, and the receipted bill shall be held as his voucher.

3. At each annual meeting the President shall call upon the Academy to choose two members, not members of the Council, to whom shall be referred

the books of the Treasurer, duly posted and balanced to the first day of the Annual Meeting as specified in the By-Laws, Chapter III, Paragraph 4. These AUDITORS shall examine the accounts and vouchers of the Treasurer, and any member or members of the Council may be present during the examination. The report of the Auditors shall be rendered to the Academy before the adjournment of the meeting and the Academy shall take appropriate action.

CHAPTER VI: PUBLICATIONS.

1. The publications are in charge of the Council and under their control, limited only as given by Article VII of the Constitution.

2. One copy of each publication shall be sent to each Resident Member, Corresponding Member, Honorary Member, and Patron, and each author shall receive fifty copies of his memoir. This provision shall not be understood as including publications in journals not controlled by the Academy, [By recent ruling, authors receive no reprints free. If reprints are wanted the Academy will pay two-thirds if the author pays one-third the cost of printing not to exceed fifty copies. The author may have as many more than fifty provided he bears the whole expense of those above fifty.] (Minutes of 1906.)

CHAPTER VII: THE RESEARCH FUND.

1. The Research Fund shall consist of moneys paid by the general public for publications of the Academy, of donations made in aid of research, and of the sums paid in commutation of dues according to the By-Laws, Chapter I. Paragraphs 2 and 4.

2. Donors to this fund not members of the Academy, in the sum of twenty-five dollars, shall be entitled without charge to the publications subsequently appearing.

CHAPTER VIII: ORDER OF BUSINESS.

1. The order of business at the Winter [Annual] Meetings shall be as follows:

(1) Call to order by the presiding Officer.
(2) Introductory ceremonies.
(3) Statements by the President.
(4) Report by the Council.
(5) Report of the Treasurer, and appointment of the Auditing Committee.
(6) Election of officers of the next ensuing administration.
(7) Election of members.
(8) Announcement of the hour and place for the address of the retiring President.
(9) Necrological notices.
(10) Miscellaneous announcements.
(11) Business motions and resolutions, and disposal thereof.
(12) Reports of committees and disposal thereof.
(13) Miscellaneous motions and resolutions.
(14) Presentation of memoirs.

2. At an *adjourned session*, the order shall be resumed at the place reached on the previous adjournment, but new announcements, motions and resolu-

tions will be in order before the resumption of the business pending at the adjournment of the last preceding session.

3. At the SUMMER [FIELD] MEETING the items of business under numbers (5), (6), (8), (9), shall be omitted.

4. At any SPECIAL MEETING the Order of Business shall be (1), (2), (3), (7), (10), followed by the special business for which the meeting was called.

CHAPTER IX: AMENDMENTS.

These By-Laws may be amended by a majority vote of the members present at any regular meeting.

OFFICERS 1908–1909.

President, CHARLES E. MARSHALL, East Lansing.
Acting-Secretary-Treasurer, WM. S. SAYER, East Lansing.
Librarian, G. P. BURNS, Ann Arbor.

VICE-PRESIDENTS.

Agriculture, F. W. HOWE, East Lansing.
Botany, WM. E. PRAEGER, Kalamazoo.
Geography and Geology, WM. H. HOBBS, Ann Arbor.
Sanitary Science, E. C. L. MILLER, Detroit.
Science Teaching, S. D. MAGERS, Ypsilanti.
Zoology, DANA B. CASTEEL, Ann Arbor.

PAST PRESIDENTS.

Prof. W. J. BEAL, East Lansing.
Prof. W. H. SHERZER, Ypsilanti.
BRYANT WALKER, ESQ., Detroit.
Prof. V. M. SPALDING, Witch Creek, Cal.
Dr. HENRY B. BAKER, Holland,
Prof. JACOB E. REIGHARD, Ann Arbor.
Prof. CHARLES E. BARR, Albion.
Prof. V. C. VAUGHAN, Ann Arbor.
*Prof. I. C. RUSSELL.
Prof. F. C. NEWCOMBE, Ann Arbor.
Dr. A. C. LANE, State Geologist, Lansing.
Prof. W. B. BARROWS, East Lansing.
Dr. JAMES B. POLLOCK, Ann Arbor.
Prof. Mark S. W. Jefferson, Ypsilanti.

COUNCIL.

The Council is composed of the above named officers and all Resident Past-Presidents.

* Deceased.

MEMBERSHIP OF THE MICHIGAN ACADEMY OF SCIENCE, APRIL 1, 1908.

(Charter members are marked with an asterisk.)

RESIDENT MEMBERS.

A

Alexander, Samuel, 822 Oakland Ave., Ann Arbor.
Anderson, A. Crosby, East Lansing.

B

Babcock, Lucy E., 428 Elm St., Kalamazoo.
Bach, Ellen Botsford, S. Main St., Ann Arbor.
*Baker, Henry B., Holland.
Barnes, Charles E., Battle Creek.
*Barr, Charles E., 111 Oswego St., Albion.
*Barrows, Walter B., East Lansing.
*Beal, Wm. J., East Lansing.
Benham, Rachel, Chelsea.
Bennett, Chas. W., Coldwater.
Bennett, Mary E., 541 Elizabeth St., Ann Arbor.
Bigelow, S. Lawrence, 1520 Hill St., Ann Arbor.
Bissell, John H., 25 Bank Chambers, Detroit.
Blain, Alexander W., Jr., 1105 Jefferson Ave., Detroit.
Bordner, John S., Bristol, Ind.
Brenton, Samuel, 121 W. Alexandrine Ave., Detroit.
Bretz, J. H., Flint.
Bricker, J. I., Saginaw, W. S.
Brown, Chas. W., East Lansing.
Burnham, Ernest, 509 S. Rose St., Kalamazoo.
Burns, Geo. P., 605 Oxford Road, Ann Arbor.
Byers, I. W., Iron River.

C

Casteel, Dana B., 1117 Prospect St., Ann Arbor.
Christian, E. A., Pontiac.
Clark, L. T., Detroit (*Parke, Davis Co.*)
Cole, Harry H., 702 Forest Ave., Ann Arbor.
Collin, Henry P., 98 E. Chicago St., Coldwater.
*Connor, Laertus, 103 Cass St., Detroit.
Cooper, Wm. F., Box 535 Lansing.
Cooper, Wm. S., 1015 Jefferson Ave., Detroit.
*Courtis, W. M., 449 Fourth Ave., Detroit.
Cumming, Jas. G., Pasteur Institute, Ann Arbor.

D

Dandeno, J. B., East Lansing.
Davies, Meurig L., Bay City.

*Davis, Chas. A., 303 S. Division St., Ann Arbor.
*Dodge, Chas. K., Port Huron.
Dunbar, Frances J., 1130 Oakland Ave., Ann Arbor.

F

*Farwell, O. A., 449 McClellan Ave., Detroit.
Fischer, O. E., 507 Field Ave., Detroit.

G

Gilchrist, Maude, East Lansing.
Gillmore, Gertrude A., 596 Woodward Ave., Detroit.
Glaser, Otto C., Ann Arbor.
Goddard, Mary A., Ypsilanti.
Grinold, E. R., Grand Ledge.
Grove, John M., 153 Hillsdale St., Hillsdale.

H

Hall, F. S., Ann Arbor.
Harvey, Caroline C., 51 Winder St., Detroit.
Harvey, Nathan A., 223 Summit St., Ypsilanti.
Hinsdale, W. B., Ann Arbor.
Hobbs, Wm. H., Ann Arbor.
Holm, M. L., 316 Capitol Ave. N., Lansing.
Hoover, J. C., 1333 Volland St., Ann Arbor.
Hore, R. E., Ann Arbor.
*Hubbard, Lucius L., Houghton.
Hunt, Walter F., Ann Arbor.

J

Jefferson, Mark S. W., 14 Normal St., Ypsilanti.
Jeffery, J. A., East Lansing.

K

Kauffman, C. H., 1020 Michigan Ave., Ann Arbor.
King, Francis M., Alma.
King, (Mrs.) Francis M., Alma.
Kleinstuck, Carl G., Kalamazoo.
Kraus, Edward H., 548 Thomson St., Ann Arbor.

L

Lancashire, (Mrs.) J. H., Alma.
*Lane, Alfred C., Lansing.
Lawrence, W. E., East Lansing.
Leverett, Frank, Ann Arbor.
*Lombard, Warren P., 805 Oxford Road, Ann Arbor.
Lyons, Albert B., 72 Brainard St., Detroit.

M

MacCurdy, Hansford, 714 State St., Alma.
MacDonald, Pearl, East Lansing.

MacMillan, J. A., 712 Washington Arcade, Detroit.
MacStanton, Samuel, 1705 Washtenaw Ave., Ann Arbor.
Magers, Samuel D., Ypsilanti.
*Manton, W. P., 32 Adams Ave., W., Detroit.
Marshall, Chas. E., East Lansing.
Mast, Samuel O., Holland.
Moxness, Dorothea B., East Lansing.
Miller, E. C. L., 66 Rosedale Court, Detroit.
Murbach, Louis, 950 Cass Ave., Detroit.
Myers, Jesse J., East Lansing.

N

Nellist, John F., 74 Housman Building, Grand Rapids.
*Newcombe, Frederick C., Ann Arbor.
Newman, H. H., Ann Arbor.
Notestein, Frank N., 627 W. Center St., Alma.
*Novy, Frederick G., Ann Arbor.

P

Patten, Andrew J., East Lansing.
Peet, Max M., Ann Arbor.
Pennington, L. H., 1212 S. University Ave., Ann Arbor.
Pettee, Edith E., 83 Harper Ave., Ann Arbor.
Pettit, Rufus H., East Lansing.
Pollock, Jas. B., Ann Arbor.
Praeger, Wm. E., 421 Douglas Ave., Kalamazoo.

R

Rahn, Otto, East Lansing.
Rapp, Dwight G., Lansing.
Reeves, Cora D., 611 Pine St., Manistee.
*Reighard, Jacob, Ann Arbor.
Robison, Floyd W., East Lansing.
Robison, Wilmer E., Lansing.
Roth, Filibert, 730 S. State St., Ann Arbor.
Ruthven, Alexander G., Jr., 821 E. Ann St., Ann Arbor.

S

Sargent, Herbert E., Kent Museum, Grand Rapids.
Sayer, William S., East Lansing.
Schryver, Anna A., 1112 Washtenaw Ave., Ann Arbor.
Scott, E. L., 304 N. Kiesel St., Bay City.
Scott, Irving D., Ann Arbor.
Seaman, Arthur E., 123 Hubbell Ave., Houghton.
Shaw, R. S., East Lansing.
*Sherzer, Wm. H., Ypsilanti.
Shull, A. Franklin, 1017 Vaughan St., Ann Arbor.
Sperr, Fred. M., 107 Hubbell Ave., Houghton.
Streng, Louis H., 335 N. Prospect St., Grand Rapids.
*Strong, E. A., Ypsilanti.
*Stearns, Frances L., Grand Rapids.

T

Taylor, Rose M., East Lansing.
Thomas, Leo, 611 Liberty St. E., Ann Arbor.
Trechsel, Wm. J., 706 Ottawa St. W., Lansing.

V

Vaughan, Victor C. Sr., Ann Arbor.
Vaughan, Victor C. Jr., Ann Arbor.
von Rosenberg, Albert, 729 E. Shiawassee St. Lansing.

W

*Walker, Bryant, 205 Moffat Block, Detroit.
Wallace, Wm. T., Hastings.
*Watkins, L. Whitney, 108 Owen St., Saginaw.
Wetmore, Mary, East Lansing.
*Wheeler, E. S., 76 Delaware Ave., Detroit.
White, Myrtle E., Coldwater.
Williams, C. B., Kalamazoo.
Williams, Gardner S., Ann Arbor.
*Willson, Mortimer, 60 Water St., Port Huron.
Wood, Leslie H., Kalamazoo, Mich.
Wood, Norman A., Ann Arbor.
Wright, Luther L., Ironwood, Mich.

CORRESPONDING MEMBERS.

Adams, Charles C., University of Chicago, Chicago, Ill.
Barlow, Bronson, Guelph, Ontario, Canada.
Bastin, Edson S., U. S. Geol. Survey, Washington, D. C.
Bell, Albert T., Neb. Wesleyan Univ., University Place, Neb.
Bullock, D. S., Casilla 75, Mishion Aureania, Temuco, Chile, S. A.
Bushnell, L. D., Madison, Wis.
Cole, Lean J., Peabody Museum, New Haven, Conn.
Dachnowski, Alfred, Columbus, Ohio.
Dixon, Chas. Y., Amherstburg, Ontario, Canada.
Duerden, Jas. E., Grahamstown, Cape Colony, S. Africa.
Edwards, S. F., Guelph, Ontario, Canada.
Farrand, Bell S., Piracicaba e de Sao Paulo, Brazil, S. A.
Hankinson, Thos. L., Charleston, Ill.
Holt, W. P., 1004 Jefferson Ave., Toledo, Ohio.
*Johnston, John B., Morgantown, W. Va.
*Kofoid, Charles A., Berkeley, Calif.
*Lander, Clarence H., 89 Arlington St., Cleveland, Ohio.
*Lillie, Frank R., University of Chicago, Chicago, Ill.
Litterer, Wm., Nashville, Tenn.
Loew, Fred. A., College Park, Huntington, Ind.
Metcalf, Z. P., Raleigh, N. C.
*Munson, Wm. H., Winona, Minn.
Nattress, Thos., Amherstburg, Ontario, Canada.
Sackett, Walter G., Fort Collins, Colo.

Scherer, Norman W., 823 Central Ave., Sandusky, Ohio.
*Smith, Harlan I, 77th St. and Central Park, New York.
*Spalding, Volney M., Witch Creek, Calif.
Taylor, Frank B., 548 Home Ave., Fort Wayne, Ind.
Ward, Henry B., Lincoln, Neb.
*Wheeler, Chas. F., Bureau of Plant Industry, Washington, D. C.
*Worcester, Dean C., Manilla, P. I.
*Wolcott, Robt. H., Lincoln, Neb.

AFFILIATED SOCIETIES.

Battle Creek Nature Club, Battle Creek, Mich.
Michigan Forestry Association.

REPORT OF THE TREASURER.

April 1, 1907–April 1, 1908.

Receipts:		
Balance on hand	$14 99	
Membership dues	143 00	
Reprints	55 56	
Sale of reports	2 50	
Contributions	16 35	
Total	$232 40	
Expenses.		
Printing:		
Reprints		$112 00
Programmes and announcements		54 45
Membership cards		1 75
Letter heads		3 50
Postage and stationery		31 50
Funeral, Prof. E. E. Bogue		10 11
Express		11 15
Janitor service		1 40
Total		$225 86
Balance on hand		6 54

PROFESSOR ERNEST EVERETT BOGUE.

ERNEST EVERETT BOGUE.

Ernest Everett Bogue was born January 13, 1864, in Orwell, Ohio. He was of French Huguenot stock on his father's side. There were nine children in the family, six of whom with the mother are still living. Mr. Bogue's early ambition was to gain a higher education, and to this end he constantly worked, earning most of the money with which to defray his expenses at school and college. He taught one term of district school; spent three years at New Lyme Institute, where he graduated in 1888, and in the fall of 1889 entered Ohio State University, from which he graduated in 1894 with the degree of Bachelor of Science in Horticulture and Forestry, and in June, 1896, he received from the same University the degree of Master of Science in Entomology and Botany.

He loved trees, plants and music, and the home surroundings and associations and education in the University all tended in the same direction.

He married on March 25, 1896, Miss Myra V. Wilcox of Columbus, Ohio, and went immediately to Oklahoma as head of the department of Botany and Entomology of the State Agricultural College, resigning in the spring of 1900, after teaching four years, to take post graduate work at Harvard University, from which institution he received the degree of Master of Arts in June, 1902. In September of that year he accepted the new chair of Forestry in Michigan Agricultural College, where his skill, originality, ingenuity and genial ways soon attracted a large class of students. He took great interest in the subject of Forestry throughout the State, visiting many of the leading farmers to encourage and help them in plans for the correct management of their wood lots, and in starting original plantations. A map of the State hung in his office well dotted with red spots showing the localities of these early efforts by farmers of Michigan. He was likewise much interested in plans to improve the stump lands in the north part of the State, and in experimenting on the wild lands of the college located in the same region.

He started a forest nursery, a part of the plan of which was to furnish young trees at cost for the farmers to plant. For the beautiful home erected he selected a congenial spot near the papaw bushes, sloping to the bank of the Red Cedar, where the dam below made a delightful place for rowing for over a mile in extent. Pitcher plants, orchids and numerous wild plants of his selection occupied suitable spots between the house and the river. With excellent judgment, he selected a nice variety of trees and planted about his new home, among them a fine grove of Norway Spruces, with the view of furnishing Christmas trees to the neighborhood when they should attain suitable size. The chief charm of the location, as he rightly viewed it, was just across the river on the farm, a virgin forest of maples, beeches, basswoods, elms and others delighting in such surroundings.

He was a man of deep religious convictions; but his creed was formulated in acts of Christian living rather than in words of belief. He was long the superintendent of the Sunday school near the college.

After a protracted illness, he died August 19, 1907, as we might say in the midst of a promising career of usefulness, as a man, a citizen, and a teacher.

W. J. Beal.

LIST OF PAPERS PRESENTED AT THE FOURTEENTH ANNUAL MEETING OF THE MICHIGAN ACADEMY OF SCIENCE.

Address by President, Man in West Norway, Prof. M. S. W. Jefferson.

Public Address by Prof. Jacob Reighard, University of Mich.: "Parental Care of Michigan Fishes." (Illustrated with lantern slides.)

1. Some Michigan By-Products, Frank S. Kedzie.
2. Mutual Interactions of Plant Roots, J. B. Dandeno.
3. Bird Protection and the Farmer, Walter B. Barrows.
4. The Claims of the Michigan Academy of Science, W. J. Beal.
5. Bacteriological Studies of Dry and Moist Soils. Otto Rahn.
6. The Cost of Weeds to the Crop, J. A. Jeffery.
7. Studies in Insect Control, R. H. Pettit.
8. Unsolved Problems in Incubation, J. G. Halpin.
9. Variations in the Proteid Content of Corn as shown by Analyses of Single Kernels from the same Ear, Andrew J. Patten.
10. More about the Botanical Terra Incognita in and around Ann Arbor, S. Alexander, Ann Arbor.
11. Some Interesting Variations of Common Plants, 10 minutes, Chas. A. Davis, Ann Arbor.
12. An Iris New to Michigan, Chas. A. Davis, Ann Arbor.
13. Seedlings of *Ranunculus Purshii*, Chas. A. Davis, Ann Arbor.
14. Additional Notes on *Chara*, Ellen B. Bach, Ann Arbor.
15. A Botanical Trip to Thunder Bay Island, C. K. Dodge, Port Huron.
16. Temperature Variations in Peat Bogs, G. P. Burns, Ann Arbor.
17. Problem of the Causes of the Formation of Mechanical Tissues in Plants, F. C. Newcombe, Ann Arbor.
18. Effect of Longitudinal Traction in the Formation of Mechanical Tissue in Stems, John A. Bordner, Ann Arbor.
19. Response of Tendrils to Traction, Warren D. Brush, Ann Arbor.
20. Effect of Swaying by the Wind on the Formation of Mechanical Tissue Maude Gilchrist, Agr'l. College.
21. Poisonous Excretions of Roots, Richard M. Zeeuw, Ann Arbor.
22. Mycorhiza on Michigan Trees, D. M. Matthews and G. A. Duthie, Ann Arbor.
23. Some Mycorhiza-forming Basidiomycetes, L. H. Pennington, Ann Arbor.
24. Can Fusaria assimilate Free Nitrogen? L. H. Pennington, Ann Arbor.
25. Is Brown-rot of Stone Fruits in Michigan due to *Sclerotinia fructigena* or *S. cinerea?* J. B. Pollock, Ann Arbor.
26. The Ascus Stage of *Sclerotinia fructigena*, J. B. Dandeno, Agr'l. College.
27. Capillarity of Cellulose, J. B. Dandeno, Agr'l. College.
28. Toxic Action of Bordeaux Mixture and of Certain Solutions on Spores of Fungi, J. B. Dandeno, Agr'l. College.
29. Unreported Michigan Fungi for 1907 with an Outline of the Gasteromycetes of the State, C. H. Kauffmann, Ann Arbor.

30. The Development of *Secotium acuminatum*, Mont., C. H. Kauffman, Ann Arbor.
31. Pleistocene Beaches of Saginaw County, W. F. Cooper, Lansing.
32. Note on the Intercalated Devonian Bed (Anderon Limestone) of the Detroit River Region,* W. H. Sherzer, Ypsilanti.
33. The Nature, Distribution, and Origin of the Sylvania Sandstone,* A. W. Grabau, New York, and W. H. Sherzer, Ypsilanti.
34. The Decomposition of a Boulder in the Calumet and Hecla Conglomerate, A. C. Lane, Lansing. (Read by title.)
35. Some Possible Uses for Peat in Michigan, C. A. Davis, Ann Arbor.
36. Peat Deposits as Geological Records, C. A. Davis, Ann Arbor.
37. On the Discovery of Permian Reptiles in Pennsylvania and the Bearing of this Discovery on the Pennsylvania-Permian Border line, E. C. Case, Ann Arbor.
38. Interpretation of the Chemical Composition of the Mineral Benitoite, E. H. Kraus, Ann Arbor.
39. Cobalt-nickel-silver Deposits of the Cobalt District of Ontario, R. E. Hore, Ann Arbor.
40. Models for the Practical Solution of Problems in Structural Geology, W. H. Hobbs, Ann Arbor.
41. A Deduction from the Study of Bridges which have been disturbed by Earthquakes, W. H. Hobbs, Ann Arbor.
42. Daily Range of Temperature, M. S. W. Jefferson, Ypsilanti.
43. Present Scope of the National Red Cross, B. S. Rowland.
44. Urticaria Following the Second Administration of Diphtheria Antitoxin, Alexander W. Blain, Jr.
45. A Course in Practical Pathology, F. P. Rouse.
46. Blood Sucking Flies, F. G. Novy.
47. The Water Supply of Detroit, E. H. Hayward.
48. Medical Inspection of Schools, Guy S. Kiefer.
49. Sanitation as a Business Proposition, Frank W. Shumway.
50. The Development of Certain Milk Bacteria at a Low Temperature, W. S. Sayer.
51. Different Forms of Immunity, V. C. Vaughan, Sr.
52. Opsonic Technique with Lantern Demonstration, E. C. L. Miller.
53. Spirilla of Relapsing Fever, F. G. Novy.
54. Sensitization and its Application to Practical Medicine, V. C. Vaughan, Jr.
55. Bacteria in Ann Arbor Water, H. D. Boyles.
56. The Hydrolytic Cleavage Products of B. coli communis, J. H. Agnew.
57. Syphilis of the Placenta, R. Genung Seland.
58. Rabies-Hydrophobia, Jas. G. Cumming.
59. The Just Claims of Biology in the Curriculum of Secondary Schools, Otis W. Caldwell, University of Chicago.
60. Shall the Study of Botany and Zoology in Secondary Schools take the form of the Study of Types? Nathan A. Harvey, State Normal College.
61. Shall the Study of Botany and Zoology in Secondary Schools take the form of Natural History? W. P. Holt, Toledo, O., Central High School.
62. A Case of Consecutive Hermaphroditism in the Killifish, *Fundulus majalis*, H. H. Newman.
63. The Bird Environment of the Ann Arbor (Michigan) Quadrangle, with Notes on the Rarer Species, N. A. Wood.

* With the permission of the State Geological Survey.

64. Permian Glaciation and the Distribution of Permian Reptiles; a Study in the Geographic Distribution, E. C. Case.

65. Reptiles of Michigan, Frances Dunbar.

66. Additional Experiments on the Color Vision in Fishes, Jacob Reighard.

67. Remarks on the Vertebrate Fauna of Northwestern Iowa, A. G. Ruthven.

68. The Ornis of Northwestern Iowa, Max M. Peet.

69. The Bird Life of School Girls Glen (Ann Arbor, Michigan); a Local Ornithological Study, A. D. Tinker.

70. The Distribution of *Lymnaea* in Michigan, Bryant Walker.

71. A Reflecting Water-Glass, with a demonstration of the apparatus, Jacob Reighard.

72. On a Method of Sub-aquatic Photography, with a demonstration of apparatus and results, Jacob Reighard.

73. A Statistical Study of Mitosis and Amitosis in an Embryonic Tissue, O. C. Glaser.

74. Observations on the Habits and Life History of *Notonectid,* S. F. Hull.

75. A Preliminary Note on Insecticides, R. H. Pettit.

76. A Possible Parasitic Habit in the Lepidoptera, R. H. Pettit.

77. Notes on a Biological Survey of the Alma Area, Hansford MacCurdy.

MAN IN WEST NORWAY.

If we can answer the question where in the world something is, we are talking geography. If we can tell why these people are there, why more numerous than elsewhere, why more happy or more wretched, we may be talking geography or we may be talking history. The conscious and purposeful activities of men, Prof. Burr tells us, belong to history, leaving their yieldings to environment and their driftings with the current for geography. I am not attempting to define my science but to illustrate its bearings by a concrete example.

On the old continent of Europe man has densely populated those regions that he has found favorable to his prosperity. He has not always displayed especial intelligence in selecting these spots; he has groped about somewhat, now settling on lands that looked promising to him, now wresting their homes from prosperous-seeming predecessors. He has made mistakes which nature has explained to him by gently withholding her bounty. But after many centuries of trial and contention he has doubtless come to inhabit the most suitable parts of the continent in greatest numbers.

Now in Norway precisely we find men spread out thinner than anywhere else in Europe. For Norway, larger than all Great Britain and Ireland, has barely a twentieth as many inhabitants. Our young state of Michigan with only half the area already has more people. The Norwegians are really so few that the part they have played in history, the contribution they have made to human development and culture is somewhat astonishing in a bare two million of people. The sea was always in the story for they came to their land by sea, by sea they moved about it of old and still today, by sea they wandered along every European shore, wresting territory they named Norman from the French king and centuries of spoils from the British islanders, even anticipating in their restless cruising the great exploit of Columbus. Today, though fewer than any European people they are fourth in world-rank as owners of merchant ships. In their own continent only England and Germany lead them. Whatever springs of racial, social or historic character may have contributed to so much of achievement, I see here the influence of an inhospitable land to which its dwellers only cling with difficulty.

Modern geography sees nothing in the Renaissance so fruitful of human culture and progress as the recognition of the ocean as man's highway. That was the gift of Columbus to his fellow men. That the world was round was known in Plato's day. That a voyage due west from the straits of Gibraltar would bring a ship in time to India had been written down for nearly twenty centuries. But that man could break away from the land and sail straight away to the ends of the earth was a view that began to dawn on men with Columbus' voyage. Beginnings of culture had already come to the races that had learned to move about the Mediterranean, groping always from point to point. Not that man voyaged for culture in those days. It was dominion, power and wealth that was sought, the neighbor's goods taken with the strong hand too often. Similar the quest of Norsemen in France and Britain, of Portuguese and Spanish in America. Once the overpowering fear of the ocean vastness was put aside it was a summer excursion, this

voyage from Spain to the West Indies. Down the steady trades by the African coast to the Cape Verds and thence on the same steady winds they sped across the Atlantic, on pleasant sunlit seas. Anything that would float was a ship, anyone that would go was a crew, anything was a sail that would hang on the yards and catch the breeze to waft them oversea to the land of gold. To return against the wind was less easy always, but then they would be rich and what matter the discomforts of the voyage? No sailors these; they had no need to be. How different in the North! On storm-swept seas with shifting winds in fog and mist. Sea-faring is a trade here that only the bold-hearted venture on. The weak and the incompetent succumb to the dangers of the sea or flee from them in terror. No school of seamanship could be sterner nor finer than the North Atlantic. This was the school in which the Norsemen learned their trade, here the Dutch and the English sailed the seas. For them the voyage to America was a constant struggle against head winds varied by furious storms. It could not be long before they met the Spaniard on his southern waters and wrested from him the treasures he brought from Mexico or Peru. Presently the Invincible Armada appeared in the English Channel and the English, sailing out in their snug, staunch little ships, met them and drove them down the gale fairly around the British islands to perish—with Spain's pretension to rule the seas. It is significant, it seems to me, that the handful of Norsemen who learned the sea-path in the middle ages should spread their name and deeds so widely and even anticipate Columbus in reaching the new world. Among continentals of this period there was much wandering of armed men as there had been even in Caesar's day. But these were land wanderings, the horse was the costly means of movement and the knights or horsemen are even today in those lands the upper class of society. Nobility was abolished in Norway in 1821, but the essential noble class in the land is its seafarers. Sunday throngs at the boat landings in West Norway show a true peasant class, dull, heavy faced and slow of movement. But the boat officers or even the crew are another type of man, men in whose bearing one sees their possession of the freedom of the earth. At home they had hardly a foothold on a rugged coast. They were not numerous enough to colonize: they founded no empire as did the English whose land is generous enough to support three hundred and sixty people on every square mile. In Norway only three per cent of the land is fit for cultivation, the rest is bare mountain, rock or forest. Eighteen inhabitants to the square mile are crowded there after a thousand years. In our new land we are already near to thirty, in Michigan, forty-five.

For the geologist and physiographer Norway exemplifies the full development of a type of landscape hinted at by nature in Northern Michigan. It is a land short of dirt. The rocky skeleton of the earth is there too much in evidence. If our earth is a ball of rock with a mere dustlike layer of soil on it, here we must bore down a hundred or two hundred feet to get at the rock. Not so in Norway, nor in New England nor in Upper Michigan.

In seven hundred miles of Norway I saw no landscape without its rock expanses often more than ninety per cent of all the view. There is also much kinship in the northern rocks. Steam by the north of Scotland south of the Orkney islands and the land border is a cliff falling sheer to the water or overhanging. Above is a gently undulating land well clothed in green growths. The rocks are sandstones that lie flat in layers. The cliff is the broken edge of the layers. Just such, only smaller, are the cliffs of Put-in-Bay in Lake Erie, at Point aux Barques on the Thumb, or at Petoskey in Little Traverse Bay,

and the rocks are just such in lower Michigan, only well seen at such points on the edges of the peninsula, for here too they lie flat in great leaves or sheets. But across the North Sea in Europe or across Lake Huron and North Bay in our Lake region we come to another type of scene, so like in both cases that nothing in external nature tells us whether we are in the old world or the new. Hummocky tumbled granites in knobs and round waves of rock descend steadily if unevenly from the land beneath the sea. Seaward the knobs are all but submerged, a fringe of countless islands all of whose contours are round and smooth but of curves that are of short radius and constantly interrupt each other, intensely rugged, but the ruggedness is one from which all minor roughness and sharpness has been removed by some polishing agency. Naked toward the sea the shoreward face of brown islet and peninsula is scantily clad with plants. These resemblances across the Atlantic rest on a broader similarity in the structure of the continent.

Glance for a moment on our map at the great chain of hollows between the mouths of the Mackenzie and the St. Lawrence, the great Canadian Lakes, as the old world calls them, including Great Bear, Great Slave, Athabasca, Reindeer and Winnipeg as well as the five that we regard as ours. They lie along a four thousand mile curve encircling Hudson Bay. Broadly speaking the rocks north of this line are all ancient, crumpled, fireworn, Archaean rocks. South of the lakes the same lie deep beneath the flat layers of Paleozoics. It is on these flat lying rocks that most of the American people live. These are the great flat sheets of rock whose edges were said to crop out at Petoskey, at the tip of the Thumb and in the islands of Lake Erie. Among them are the Carboniferous rocks that carry our coal beds.

In Europe a similar line of depressions may be followed through North Sea, Baltic, Gulf of Finland, Lakes Ladoga and Onega and the White Sea, under water most of it here, it stands so low. Here again for a rough description we may say that the rocks to the north are all the ancient gnarled Archaean; to the south appear the flat lying layers on which live the mass of Europe's people, English, French, German and Russian. It was a sample of this that we saw in the Orkneys and northern Scotland.

These contrasts in the land nature are fairly well followed by the tree sorts on the two regions, to the north, needle-bearing conifers, to the south, broad-leaved, deciduous trees, though there are numerous excursions of either sort across the boundary, as for instance the pines on the Paleozoics of the southern peninsula of Michigan.

The Baltic Shield of Archaean as has been said displays a type of land form strongly hinted at in the Archaean V south of Hudson Bay. The northern rocks in both cases are fused, molten, crystalline and hard, those of the south dull, earthy, layered and soft. Millions of years of weather had rotted and softened both kinds till their surfaces lay deeply buried in the resultant soils when another and singular thing befell. Its effects were much like the dragging of innumerable brush harrows southward across the Archaean areas and over the border of the southern cover layers.

Details belong to geology. It is the story of the Ice Age. The process swept off the decayed and softened surface portions of the Archaean rock, baring firm, sound, unweathered rock below, which is smoothed and polished at the same time that it left it hummocky and nubbly as its gnarled and crumpled structure demanded. As the sweeping process did not extend far into the southern areas their rocks were rarely stripped, but rather received the sweepings from the north upon their own soils. Thus it happens that

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our fields in southern Michigan have abundant mineral matter from the country north of our Lakes, and Scandinavian rock waste abounds in England, Germany and West Russia. It was in that sweeping process that our field stones, so much firmer and more suitable for building purposes than the rocks found by deep borings under us here—were imported, mostly from Canadian territory.

We know our north country to be a wilderness of rock and forest, therefore a vacation ground for the denser population to the south. It is likely always to remain so, not as any result of the newness of American settlement, but it rests on physiographic grounds as in our European example after long centuries of effort. The physiographic contrast in Europe is stronger than here as we shall now see and where our population falls off from thirty to the mile south of our Lakes to three or four on the north, Germany with two hundred is to be contrasted to Norway with eighteen.

It is precisely in Western Norway that the land is rockiest, there where the sea penetrates deeply into the land in the three great Fiords, Hardanger, Sogne and Northfiord, extending even sixty miles from the ocean. Offshore is an island swarm identical in origin with the Ten Thousand Islands of Georgian Bay and innumerable channels between. The waters are still, so still it is hard to believe them a portion of the Atlantic Ocean, but any wider space between the islands at once sets our little steamer rolling violently. Nubbled, rounded and hummocky are the rocks all along; on the face toward the land picked out with heather in every crevice but on the ocean side brown and bare. Where shall man live in such a region? We turn a corner to the eastward and enter the harbor of Bergen. It is one of the best footholds west Norway affords. To appreciate it better let us turn our backs on the city as if starting on up the coast to northward and there we see man again losing his foothold on the crumpled rock. The houses seem to cling as long as the slope is gentle enough to let them stick, but it is dirt that is scarcer even than houseroom here.

Bergen lies at the mouth of a mile-wide valley that continues for several miles to the south and west until it comes again to the sea. It has no river but lies flat-bottomed and floored by park-like fields and estates between cliffs a thousand to fifteen hundred feet in height. It needs but a gentle depression to sink the valley floor beneath the sea and produce another sound-like passage among islands. Such it was not many thousand years ago. This soil gathered on the sea bottom, the washings of the land, and almost every foothold man has found in the region has originated in a similar way. The seventy thousand people find it footing scant enough. We may see the city streets climbing high on the valley wall, macadamized, supported by granite walls where the zigzags double on each other and provided with iron hand rails for the foot passenger. The steepness allows the houses to have street entrances at each story. This portion of the city a member of the Norse parliament told me, was not used for residence by the well-to-do classes, not because it was not good for house sites but the land was so cheap there that the poor crowded them out. He did not entertain the idea that there was a geographic reason for this cheapness. But we may go far above the highest of the houses, following the admirable road to a height of a thousand feet on a shoulder of hillside where we may rest at a little restaurant and look out across the whole region, solitary upland, populous valley, fiord, island and Atlantic. Behind the restaurant a narrower path leads on and we soon have before us a sample of the stuff the land is made of. We are at an elevation of twelve hundred feet on a mile wide bench. Across the

foreground runs the path of crushed stone resting in the heather on a foundation of peat that makes it yield like velvet to every footstep. Further back rises another seven-hundred-foot cliff of purplish gneiss, almost entirely bare. There is little frostwork here. It is too mild under the breath of the Atlantic.

One sees little rock that has fallen from above. A little further the truth of this observation is emphasized by the clearness with which a single exception stands out on the valley wall; above a light gray scar, below the light gray pile into which the falling rock resolved itself. Every flat surface has its peaty soil and growth of heather. The rocks are everywhere wet and glistening. Down at sea level the rainfall is double that of Michigan, up here probably more still. Plants grow on any pretense of soil. Looking from the summit landward I estimate the bare rock as forty per cent of the landscape here. In every hollow a lake gathers with water plants and mosses busy filling all about the border. So if we turn and look below to the bench above the restaurant. The heather cover is closer here. And the bog plants have come nearer to filling their pool. But green as the whole ground is, it has no soil that man can use; only heather and moss can grow upon it. Man is confined to the narrow valley, the great upland surface of the land has no inhabitants. Northward we shall see more desolation, slopes of birch at the waterside, above that heather and over that the desert of bare purple rock and snow.

We turn presently into the Northfiord, passing an occasional group of little houses at the water's edge. For hour after hour one must estimate bare rock the larger part of the landscape. Of what plants are there, only a narrow stripe of yellow grass along the fiord edge at the old sea level is of use to man. This fiord is some sixty miles in length to hardly three in width. It is enclosed in strong slopes descending from snow-spotted uplands two or three thousand feet above. In the sunlight it is grand but gloomy more often when roofed over tunnel-like by clouds that hang below the summit of the walls on either hand. At the fiord head is a mile-square patch of land that has inhabitants. It was anciently a delta of mountain streams built into the head of the arm of the sea when the land stood a hundred and fifty feet lower. Looking back over the fiord from this terrace, the scene is one of greater promise for men. Here on the terrace and about the lake above 368 people dwelled in 1904. The valley has been settled a thousand years. The land under such circumstances is very precious. It has no ascertainable price. It is not bought or sold. Each point has its own name and the people all have that name too. Thus the main settlement Loen has thirteen peasant proprietors and "always has had." Each of these families is named Loen, the individuals being distinguished by their christian names commonly with the addition of their father's name, as Marcus Andersen Loen, Rasmus Johansen Loen, Anders Marcussen Loen and so on. Frequently individuals are found with the name of a neighbor settlement, but the rarity of this denotes fixity of residence through the generations.

Closer to the shore are more signs of men in the landings where are stored the things that come and go in boats. And there is no other approach. There is a road up to the lake, there is a steamer on the lake, and the valley beyond finally heads up at the glacier and cliffs leading to an upland a mile above the sea. All who go up the road come down. The skipper of the steamer declines your fare on the up trip. You will come back later, you may pay then. If you raise your eyes from the landing they sweep up a long slope of birches a little striped by rock and snow falls from a niche in the

cliff, then up a steep brown face of rock to a platform at three thousand four hundred feet above the fiord steamer at the landing. If we take the camera and climb, in five hours we may stand above and see the whole valley spread out in bird's eye view. Under us the fiord, the terrace on which stand the scattered houses of Loen and the road beside the river to the lake, three miles away.

Both lake and fiord are of fresh water here, tho the tide rises and falls four or five feet twice each day. No salt can be tasted in the fiord for many miles toward the sea. It is in such spots as this on each of the branches into which the fiord divides at its head that all the inhabitants of this part of the kingdom must live. The area here is small, the most distant wall being barely twelve miles away, but very hazy and blue with the water vapor in the air. If we walk along the road we find the scene park-like with the mountain walls always towering far above the trees, while the far-from-silent river alongside puts a good deal of action into the scene, especially on the hot days, when the ice above melts freely. During much of this walk we have a summit in the background six thousand six hundred feet above us, a mount Washington with its feet at sea level. Presently we pass the last fall and come to the level of Loen Lake. A glance back shows us the cliff we just ascended with its crest now above the clouds. Just before us is a tiny farm with all its lands. Over across the foot of the lake is a yet tinier one. This is known as a one man place. When the son was grown he had to emigrate. All the farm lands are in sight. They are not cultivated by machinery. Part of the water that leaps so abundantly from above is utilized on one farm for a fulling mill, part of it for the farm grindstone, or tumbling wastefully over the grass when the sluice is closed.

There is a good deal of wood in the valley on all the lower slopes. From this the tips of the birches are cut when tender and dried to eke out the scanty store of winter hay. Further back the Scotch spruce is still abundant. Houses here are of course of wood and though essentially log cabins that have been *tamed* by a thousand years of experiment into a curious affair of dressed and dovetailed timbers. It is made of planks four inches thick, and tongued each to the one above. There is no frame. The planks are dovetailed together at the corners, and partitions and floors are dovetailed through the solid sides. When the windows are sawed out, a slab is nailed across the space between them to hold the planks there together until they are supported by nailing to the window frame. Outside these planks goes an outer sheathing of inch-thick clap-boards. When roofed with slate such a house gives an effect much like that of our frame buildings. The mere log cabin only occurs on the mountain pastures where the cows pasture through the summer and the girls go up daily from the fiordside to care for the milk. These and the poorer houses are roofed with sod, often underlaid by birch bark to keep the rafters from rotting. The better buildings are everywhere roofed with red tile.

The brick and stucco houses of the cities are often of excellent design. Above the Loen Lake where ice and snow abound the slopes are full of the work of ice, wrecking and burrowing. This happens not merely at the summit of the cliff where the ice must fall over the edge, but at every point on the slope where it rests there a great hole is dug. Little isolated glaciers that lie high up on the mountain side are always margined on the upper side by a cliff one or two hundred feet high as if showing how much the ice has recently sunk itself into the rock. Just below, if we are above the level where ice sometimes melts, lies the rough heap of moraine, big as the glacier itself

A COMPLETE TYPE OF LIFE IN WEST NORWAY.

and witness to its excavating power not only by the mass of rocky debris but also by the fresh unweathered gray color, while the cliffs all about are brown and purple.

Up beyond Loen Lake the valley is not unlike. The walls are steeper here, the scene is grander, for the upland surface is a mile above us and on it for three hundred and sixty square miles here rests the greatest glacier of Europe. There is little footing for continued human occupation, though. Near the lake head stood in 1904 two little settlements of Bodal and Naesdal, with sixty inhabitants between them. In the following winter almost every individual perished in a great wave from the lake, caused by the fall of an enormous mass of rock from the cliff above.

Above the lake head the ground is too stony to cultivate. We may go up through the alders for two miles and emerge on a glacier bed which the ice abandoned only a few years ago. The trees end at the wall like ridge of stones the ice had earlier pushed before it. Upon the valley floor we now perceive the river winding from side to side strewing it all across with stony waste. Beyond, the glacier closes the valley, dull and dirty looking under the clouds, but glittering white when the sun bursts forth. We see then that there is little dirt upon it. Mostly it is white, clean ice resting on clean coarse gravel, with our river issuing from a blue cavern in the end.

If now in our search for places where men may dwell we climb five thousand feet above and look across the valley of the Loen Lake to the upland, the midsummer landscape of snow and ice shows little promise. From the highest point in the region the prospect is even worse, a broad expanse of white picked out with rock. Such is west Norway seen from on top. Of such a land only the edges are usable. We saw some bits of habitation on the old sea bench beneath. At Froen it appears as a distinct bench on the landward side of one of the coast islands; dwellings and bench appear plainly. Outside on the ocean border where the cliffs are stripped bare by winter storms, a line of caves with a faint bench between marks the same ancient submergence of the land. It would hardly be possible to maintain life in a spot so exposed but just within the entrance to the nearest fiord we find human dwellings in a place only better in its shelter from the ocean winds. They are not summer camps, but permanent homes. Further up the fiord is a tiny farm that seems to me the completest type of human life in west Norway, though there may not be many like it.

A dike of softer rock has weathered back and formed a gully with soil on its floor. To right and left is only barren cliff of rock. At the water's edge the boathouse, the boat moored beside it; in the middle of the narrow stripe of grass the dwelling, and high above the shed that serves for barn; all three combine to show the Norseman making the most of every scanty patch of earth as he clings to the edge of a rocky land, ready always to fare out upon the waters.

MARK JEFFERSON,
Ypsilanti, Mich., April 3, 1908.

THE CLAIMS OF THE MICHIGAN ACADEMY OF SCIENCE.

The State Academy of Science was organized in June, 1894. At a meeting of the advisory board, it was unanimously agreed that it have for its principal object the study of agriculture, archeology, botany, geography, geology, mineral resources, zoology of the State of Michigan, and the diffusion of the knowledge thus gained amongst men. You observe that provision was made at the first meeting for investigations in agriculture, and at the first meeting for the presentation of papers, one paper was read by Manly Miles, M. D., entitled "Futile Experiments for the Improvement of Agriculture." At the next annual meeting A. A. Crozier spoke on "Recent Advances in Agricultural Botany," and Prof. Walter B. Barrows spoke on "Food Habits of Michigan Birds." At a field meeting of the academy held at the Michigan Agricultural College, June 13th, 1896, formal permission was given for the organization of a section of agriculture with Prof. Clinton D. Smith as chairman. The agricultural section of the academy was organized at the request of some twelve persons connected with the teaching force and experiment station of the Agricultural College, with several objects in view; one of which was to furnish opportunity to professors of the State University, colleges and normal schools to become interested and instructed in the relation of science to agriculture.

At the seventh annual meeting of the Academy held in Ann Arbor with Prof. J. A. Jeffery in the chair of the agricultural section, in the opinion of those present, an excellent program was furnished, consisting of "Some of the Relations of Botany to Agriculture," Dr. W. J. Beal; "Some New Demands upon Agricultural Education," Kenyon L. Butterfield. Three persons were present, including the chairman and the two who read papers, and they incidentally began to cite the statement of John Hopkins and the log. It needed no argument to show that the program did not draw.

At the eighth annual meeting held in Ann Arbor, Prof. Jeffery in the chair of the agricultural section, there were four papers read; one by J. J. Ferguson, instructor in agriculture; one by a student, George Severance, a senior of the Agricultural College; one by Dr. W. J. Beal, and one by Kenyon L. Butterfield.

There was a single visitor present, C. A. Davis, then instructor in forestry at the University, who came to listen to the paper by Dr. Beal on "What Shall the Michigan Farmer Grow for Fence Posts and Telegraph Poles."

A strenuous effort was made to make the ninth annual meeting attractive to outsiders, with just a little improvement over the other meetings by way of attendance.

The officers of the academy had claimed all along that the section of sanitary science could not be successful unless the section met at Ann Arbor, where the meeting would receive support from the faculty and students of the medical college. It began to dawn on some of the agriculturists, why should some ten of the members of the agricultural college faculty go to Ann Arbor with papers to read solely to their own number? To be brief, permission was granted to hold the agricultural section at the Agricultural College, thus securing more easily a better program and larger attendance,

besides saving time and expense of busy men at the college. With meetings held at East Lansing the attendance has been good, though by no means equal to that of a local circus. What is a good attendance at meetings of scientific students, either local, state or national? Depending on where the meeting is held, and more or less on the advertised program, it ranges from ten, twenty, not to exceed fifty persons, except rarely when it reaches a hundred or more. Meetings of the National Academy of Science for presenting papers meet twice a year. At one session a certain mathematician, Professor Pierce, of Harvard, was prepared with a paper. When called on he glanced over those in attendance, remarked that there was only one member of the academy who could understand his paper, and as he was not present he thought it not worth while to read the paper, and it was not read.

W. J. Beal.

MUTUAL INTERACTIONS OF PLANT ROOTS.

J. B. Dandeno.

The idea is not new that plants, in their ordinary activities of life, produce upon the soil, through the medium of their roots, an effect which is shown frequently in the succeeding crop. This succeeding crop is usually, though not always, smaller than the preceding, and smaller than it would be if steps be taken to modify the soil in such a way as to counteract this effect. It has long been known that roots of plants excrete substances which usually react acid. Many plants, of which corn may be taken as a type, give off material which is not acid, and it is quite probable that the character of the substance liberated, is as diverse as the plants themselves. Up to the present, very little is known with respect to such substances, either chemically or otherwise, and, in the practice of agriculture, it has never been recognized that such substance, if any be excreted at all, could have any bearing upon the fertility of the soil. When soil had become poor, the chemist pronounced such soil to be lacking in the ordinary inorganic nutritive substances, or plant food, as it was called. But when seedlings are used, and distilled water as the medium, the matter of external soil food is entirely eliminated, and yet, in many respects, results which are similar to those produced in soil, are brought about. This subject, of course, is quite closely connected with that of the interaction of the roots upon one another, and this is the phase of the question, particularly, discussed here.

The object of the experiments relating to these questions was to gain some exact knowledge of the material excreted by roots, and of the interactions of the roots of one plant upon another.

After the preliminary experiments and observations had been made, two very prominent things began to be apparent. During the first twelve to thirty-six hours, certain results developed, which were different from those obtained from seedlings grown longer than thirty-six hours. As a rule the growth of the radicles of two different seedlings, when grown together, was greater than when grown separately for the first eighteen to thirty-six hours; after that, the difference was generally the other way.

In the case of experiments on growth of radicle for the first period, the difference was generally greatest when in smallest amounts of water; but the period of augmented growth was much shortened. In the second period, that *after* thirty-six hours, the results varied, but the quantity of liquid root-medium played some part in the results.

For the first period, the seedlings for the test were taken when the radicles had grown about fifteen to twenty mm. long. These seedlings were set aside for a period of from sixteen to thirty-six hours and the growth of radicle measured. The different species of seeds used, were placed in 25 cc. vials in pairs. For example, when seedlings of the species A and B were compared, 10 pairs of A were put in 10 vials, 10 pairs of B were put in 10 vials, and 10 pairs made up of one of A with one of B were similarly placed; and in a given time, the total growth of the seedlings A, when grown with B was compared with that of A when grown with A.

As a general rule, the growth of both A and B, when grown together,

was greater (for the first twelve hours) than when A accompanied A, and B accompanied B. After about twenty-four hours, this result was not nearly so uniform, and after thirty-six hours, it was nearly always reversed. The plants which showed the phenomenon most strikingly were corn, and squash, and more so with the squash than with the corn. The other plants examined were wheat and buckwheat, lupine and corn.

For the second period, the growth of both radicle and plumule was examined, and the period of time was longer than thirty-six hours, and including an extent up to about four weeks. The measurements of amount of growth during the second period could not be so accurately made on account of the extensive root system and the increase in number of leaves and branches. But, in a general way, most of the results were so marked and so uniform that the actual results were as convincing as those of the first period and far more pronounced. In the second period, the results were emphasized by growing several—ten or twenty—together in the same vessel, instead of a few, as was the case during the first period.

In a general way distilled water was the medium which proved most satisfactory, because it gave results most uniform. Tap water and salt solutions were used also, but these seemed to involve problems so complicated as to be considered beyond the bounds of the subject at present under particular attention. The general results of the experiments in the second period were, in a sense, uniform, and were about as follows:

When plants of the species A were grown with B, they did not develop so rapidly, nor produce so much growth in a given time as when grown with A. This was very marked with the combination of squash and corn, and especially so with the squash; that is to say, of the two plants under consideration the squash suffered most from the association.

It ought to be said, perhaps, that it was the root system which offered most striking contrast, though the stem system showed similar results.

When it seemed conclusive by repeating experiments with some plants, and by using different plants in combination, that these general results were uniform, the real problem of the subject presented itself:—What could be the cause of these peculiar phenomena?

It seemed apparent that the liquid in which the plants had been grown, should be the substance which was concerned directly and so this was examined from the physiological side, in some detail. As is well known to plant physiologists, roots and rootlets shed off to the surrounding medium a large number of loose cells from the cap, and from dead root hairs. By the aid of a compound microscope, these cells can readily be seen floating around in the water drops, and such cells soon decompose by bacteria, which also may be seen in large numbers. After a few days, even aquatic fungi appear. These fungi live upon the decomposing cells, and upon the excreted organic matter of plant roots. Moreover, those fungi and bacteria excrete in turn a product upon which other bacteria and fungi may act. Therefore, the liquid medium of the roots becomes contaminated with at least two things directly—(1) plant cells set free by the roots and (2) soluble matter. Indirectly, bacteria and fungi which prey upon these substances, excrete other products into the liquid. As to the chemical nature of these substances, I am at present unable to pronounce further than that they are complex, organic substances which rapidly decompose. In fact, because of this instability, it is practically impossible to analyze them at this stage, for the simple reason that they are not the same one day as another, from

one hour to another. But it is highly probable that the character of these complex substances set free by roots, is peculiar to the species of plant.

These substances, including the liquid excreted by roots, the decomposing loose cells and the bacteria and fungi, seem to act injuriously towards the roots of other plants when such roots are immersed in liquid containing them. And the experiments showed that material excreted from corn checked the growth of the squash roots more than material excreted from the roots of the squash checked the growth of the squash.

Working on the assumption that such excretory substance was the cause of the phenomena mentioned, it was concluded that it would be a comparatively easy matter to remedy the culture medium (distilled water). Several means were employed (1) close filtering; (2) shaking up with filter paper, paraffin pellets. gypsum; (3) passing oxygen through the solution; (4) adding a little hydrogen dioxide. Carbon black was not employed, because it had been used with great success at the Department of Agriculture, Washington, and elsewhere, and no doubt it would be as effective as any here mentioned. Moreover, the writer has used carbon black off and on for many years for absorption experiments, and for such work as that now employed, so it was thought unnecessary to apply it here. Pieces of coke are very convenient and useful, especially for suspended material and loose cells.

The action of all these substances is partly a physical one. The substances in the liquid, whether in solution or not, are attracted to the filter paper or gypsum and held there mechanically. The root liquid can then be improved. But the most important effect of these inert bodies on the liquid is to remove the excreted loose cells, and not so much on the substance in solution. This is borne out by the fact that a liquid; shaken up with gypsum, talc, etc., contains still small quantities of substance in solution, but this substance does not seem to be injurious to the roots, at least not for a considerable length of time.

The most remarkable operation is that of the application of oxygen, whether used directly or in the form of hydrogen dioxide. It seems that its action is to oxidize bacteria and also the cell content of the loose cells, and thus produce compounds not directly injurious to the roots of the plant excreting them. It is now known that plant roots are themselves oxidizing agents, and this fact throws light on the whole question. When oxygen is passed into two culture liquids which have been in use for a week or ten days, the one used with corn and the other with squash, it improves both, but it improves the corn root liquid more for corn than it does for squash, and the squash root liquid more for squash than for corn. In other words, it appears as though the oxidizing action of a plant is more effective against excreta of its own roots, than against those of another species. The products of oxidation are apparently then not the same for the two plants. One might suggest that this is a result of *adaptation*, but perhaps this might seem to be too "far-fetched."

To account for the augmented growth during the first period, is not such an easy matter, but it might be explained on this basis. During the first twelve hours, there could be little decomposition either bacterial or from direct oxidation. The liquid excretion from living cells of the radicle is apparently the only substance to be taken into consideration, and it seems probable that this excretion might be stimulating to the growth of the radicle of another species which might be present, and yet more or less inhibitive to the radicle itself. This is more or less theory, because it is very difficult to get experimental proof, but it should be remembered that the only point

wholly theoretical, is the assumption that undecomposed excretion (in small quantity) is stimulative to the growth of a radicle of another species. And there is experimental proof that toxic substances like copper sulphate when in very minute quantities, stimulate plant growth.

As has been pointed out, the mutually injurious effects of plant roots would likely be very variable according to the species used, some distinctly harmful, and perhaps some neutral or even beneficial; though with the plant here examined none seemed materially beneficial. But it must not be forgotten that the plants used were seedlings which had a supply of organic food ready prepared, and were dependent only upon a supply of water and air. These conditions are not sufficient of course for plants which require other matter than water from the soil. When the question of complex nutrient solutions, or soil solutions, are taken into consideration, the question becomes so complicated that, beyond a few steps, it is at present not safe to go, for there is one thing very apparent that as soon as even one substance is introduced into the distilled water used as a root medium, the question becomes very complicated. At all events, there is one prominent deduction to be made from the distilled water culture. To get good growth, plants must be protected against their excretion, and against that of other plants. This protection is accomplished by oxidation, decomposition, and reduction of excrementitious organic compounds. From this it seems to me the question of crop growing is not so much one of fertilizers, as generally understood, as it is one of the purification of the soil from root excretion, and of a knowledge of what plants are mutually least injurious to one another. It is also clear that an important function of barnyard manure is to supply an abundance of bacteria which rapidly decompose the excretion, and reduce it to simple, non-injurious substances.

A résumé of the conclusions results in the following:

During the first 24 to 48 hours, two seedling plants when grown together, often promote the growth of each other, but afterward, bacteria and aquatic fungi prey upon the dead cells of the root cap, and upon the dying root hairs, producing an excrementitious substance decidedly injurious to the roots.

It is mainly the excretion of these fungi and bacteria which directly causes the injurious effects.

When a plant is watered with plant juice, the first set of bacteria or fungi which attacks the juice results in a harmful matter; and it is not until the harmful matter is decomposed by other bacteria or by chemical action set up by manure, that the injurious causes are removed.

The excretion of fungi is usually injurious to plant roots, excepting in the case of a symbiosis of mycorhiza and host; but from certain preliminary experiments it appears as though the excretion of such mycorhiza is injurious only to plant roots other than those of the host.

And finally:

The loose cells set free by roots are the prime cause of injury*, though not the direct cause. They furnish food for fungi and bacteria, but it is the excretion of these fungi and bacteria which causes the injury.

Mycorhiza shows a step further in adaptation, inasmuch as they attach themselves to the roots, the first step being the attack on root-cap cells and root hairs set free.

Remedies:

* For the root-cap cells alone the loose cells as estimated amount to nearly one-half as much as the total root.

Remove the free cells before decomposition sets in. But this is not practical, excepting to show the cause of injury.

Remove the excretion by oxidation, boiling, shaking up with powdered talcum, carbon black, etc.

Counteract the effect by supplying decomposing vegetable matter, e.g., barnyard manure, or other form of so-called fertilizer whose character should be known to be such as would remedy the particular disease.

Agricultural College, April 17, 1908.

SOME INTERESTING VARIATIONS OF COMMON PLANTS.

CHARLES A. DAVIS.

From time to time, peculiar variations in the vegetative or floral structures of certain of our native plants have come to the notice of the writer, and they are brought to your attention at this time with the hope that other observers will put upon record their notes along the same, or similar lines. Such observations, as isolated facts, have little value and may not seem worthy of preservation in permanent form, but a sufficiently large series of them, after study and assimilation by some one, may shed important light upon a question which otherwise it would be impossible to illuminate.

The record of facts of variations, sports and mutations in these days, are of especial interest, since, at any time they may furnish important clues to the further clearing up of the obscurity in which certain phases of the history of the development of our present flora is now immersed. While no such claim is made for the present paper, it is hoped that notes contained in it will not be without interest.

For a number of years occasional specimens of plants normally with opposite leaves have been found, in which some, or all, of the branches and leaves were in true whorls of three. The duplication of parts sometimes occurs on a single branch, or twig, sometimes throughout the entire plant, except the flowers, which, so far as observed, are normal. The appearance of the parts of the plants thus affected is not that of fascination, even of the slight est degree, but is perfectly normal, the odd buds of the whorl always developing symmetrically with regard to the others, and on alternate sides of the stem, the three dividing it exactly into thirds at perfectly definite angles, the series forming six instead of four ranks. Sometimes the secondary branches of shrubs have their buds and leaves normally placed.

The plants in which this peculiarity has been observed are the following:

1. *Acer rubrum* L. Red Maple.

A single small branch on a medium sized tree. There may have been other branches of the same sort on this tree, but none were noticed.

2. *Æsculus Hippocastanum* L. Horse chestnut.

A single twig on a young tree. All other branches opposite.

3. *Hypericum Ascyron* L. Great St. John's Wort.

Entire plant.

4. *Syringa vulgar s* L. Lilac.

A single short branch on large bush.

5. *Fraxinus Americana* L. White Ash.

A sprout from stump.

6. *Sambucus Canadensis* L. Common Elder.

A single young, vigorous shoot, in a considerable tract of smaller ones, has been seen with all of the leaves in whorls of three.

7. *Lonicera Tartarica* L. Tartarian Honeysuckle.

This shrub shows this variation more frequently than any other species, and it is usual here at Ann Arbor to find some of the branches on most individuals thus modified.

8. *Heliopsis laevis* Dunal. Ox-eye.
   A single plant with all of the leaves in whorls of three.
9. *Helianthus* spp. Sunflowers.
   At least two different plants of this genus have been seen with all of the leaves in whorls of three.

A very different variation was called to my attention in the spring of 1907 by Miss Frances Stearns, of Adrian, who sent a series of flowers of *Ranunculus delphinifolius* Torrey, the Yellow Water Crowfoot, in which the petals were all trifid, the three lobes being of about equal size, and the lobation extending in most of the examples quite to the gland situated at the base of the petal; some of the flowers, as is frequently the case in this species, showed a tendency towards doubling, more than five petals occurring, but the extra petals were as deeply lobed as the others. Some of the plants were kindly furnished by Miss Stearns but the later flowers developing from these did not have lobed petals, although a few of them showed notches along the margins. It was reported by the collector of the specimens that all of the plants, over a considerable area of swamp in which it occurred, had the same peculiarity. This variation in the flowers of a species of *Ranunculus* is the more interesting because no record of similar parting of the petals in any plant of the family seems to have been made; no species of *Ranunculus* or any of the related genera has any but entire petals, the various parts of the flowers were normal, and the color of the petals had no suggestion of green in it, thus the variation does not seem to be a case of phyllody, although from analogy to the vegetative leaves, the lobing would suggest that this might be so. Plants propagated from those received, have been kept over winter and it is hoped they may bloom in due season, and that seed may be obtained from them in order to determine whether this is a mutation or simply a sport.

Ann Arbor, Mich.

SEEDLINGS OF *RANUNCULUS PURSHII*, Richardson.

CHARLES A. DAVIS.

This northern species was collected by the writer in 1905 in various places in the valley of the Menominee River, and the differences which the specimens collected showed from the published descriptions and illustrations, at first led to the conclusion that the plant found was distinct from *Ranunculus Purshii*; later studies, however, seemed to point to the identity of the two plants, as the differences were finally decided to be of such character that they were immaterial. A quantity of mature fruit was collected, however, and a series of germination tests were made in the spring of 1906 and the seedlings somewhat carefully studied.

The seeds were germinated both in water and on moist soil, and of the two sets the development was much more rapid in the soil than in the water; the cotyledons were very small, 2 to 3 mm. long by 1.5 mm. wide, elliptical, about half as broad as long, and in both soil and water persisted for some weeks; the petioles elongating until they exceeded the length of the cotyledons, which also increased in size until they were nearly doubled in length.

The first leaves were palmately three-lobed, 2 mm. wide by 1.5 mm. long, with petioles 1.5 mm. long, and no others except three-lobed ones developed in the water, although, on some plants, four or five leaves appeared while the plants were under observation; a number of plants were kept submerged, and, while they developed more slowly than those whose leaves reached the air, and had smaller leaves with rather more slender lobes, the plants grew as long as they were watched—several weeks. In the terrestrial plants, the fourth leaf to appear had the basal lobes divided and the terminal lobe toothed. There was no appearance of lobes or teeth on the first three leaves which appeared on any plant; the stems of the seedlings developed very little in any of the plants.

The roots of the aquatic specimens were long, very slender, and had but few simple branches; those of the terrestrial individuals were not examined.

From the behavior of the seedlings, under the two sets of conditions to which they were subjected, it seemed apparent from the rapidity of growth and vigor of the forms growing in the soil as compared with those in water, that the plant is normally terrestrial, although in the localities where found, it was only seen growing in the water with leaves either floating on the surface, or slightly submerged, and the roots and stems suspended in the water without definite attachment to the bottom. From these facts it would seem that the aquatic habit had been acquired rather recently, and the plant is much more likely to be found growing in moist or wet places out of water, than its near relative *Ranunculus delphinifolius*, Torrey, the common Yellow Water Crowfoot, which, while it survives in the bottom of dried-up pools during the summer and fall, is, in its typical form, an aquatic plant during its flowering and fruiting season.

In Britton and Brown's Flora of Northeastern North America, and Britton's Manual of the Flora of the Northern U. S. the habitat of *Ranunculus Purshii* is given as "moist soil," but as already stated, in the several localities where it was found in Menominee County, notably near Hayward Lake,

five miles east of Ingall's Station on the C. and N. W. R. R., T. 34 N., R 26 W., the plant was always found growing in water from one to two feet deep, but Torrey and Gray, Flora of North America Vol. I p. 20, describe R. limosus, Nutt, as "sub-aquatic," and this species has been identified, rather carelessly, it seems to me, with Richardson's *R. Purshii.*

Ann Arbor, Mich.

A BOTANICAL TRIP TO THUNDER BAY ISLAND.

C. K. Dodge.

Thunder Bay Island is in Lake Huron about twelve miles east of the city of Alpena, Alpena Co., Mich., and four miles east of North Point, the nearest mainland. It contains about 145 acres. On the east side is the light house, on the west side, the United States Life Saving Station, at present managed by Captain John D. Persons, a genial and intelligent man, who welcomes geologists, botanists, and all scientists. The island is a solid limestone rock, just above the water, built up ages ago. The soil covering is generally very light, and in many places a considerable distance away from the shore the rock is exposed. In the center, the drift may be several feet thick. The island is occupied only by light house and life saving employes and their chiefs. Very little attempt is made at cultivation of the soil, even for gardening. Near by at the north west is another rock rising above the water, and covered with drift, called Sugar Island, and another one called Gull Island not occupied at present, both showing some signs of former habitation, probably by fishermen and being well covered by vegetation. North Point is a projection of drift-covered limerock from the mainland to the south, partially dividing off from the Lake the body of water called Thunder Bay.

Thunder Bay Island is a veritable emerald gem out in the sea and should have had a name corresponding to its beauty. It was visited June 22, 23 and 24, 1907, mainly to rediscover and secure specimens of a dark-fruited thorn, at present known as Crataegus borealis Ashe, reported as found there by Prof. C. A. Wheeler over ten years ago. After a thorough search not a thorn of any species could be found on that island. But on Sugar Island fine specimens of Crataegus punctata Jacq. were noticed in abundance, not yet in bloom, nor did they bloom till the first week in July. Failing to find the main object of the search, attention was turned to other plants. The principal tree of Thunder Bay Island is Abies balsamea (L.) Mill. of small size growing thick especially on the western half. In a few places Thuja occidentalis L., Larix laricina (DuRoi) Koch., and a very few of Fraxinus pennsylvanica Marsh. were noticed. Among these also were many small shrubs of Acer spicatum Lam., being of larger size and very abundant on Sugar Island. One fine speciman of Sorbus americana Marsh. was noticed. In many places Alnus incana (L.) Willd. was abundant. Not an oak, beech, hickory or elm was seen. Salix glaucophylla Bebb occurs at the north end. Juniperus sabina L., bearing fruit in abundance, covered the ground in many places, having the appearance at first of a Lycopodium and at North Point on sandy ridges it was abundant. At the south end Malus malus (L.) Britton was frequent, low and scraggy, and in full bloom

June 24. It is reported that many years ago a cargo of apples was wrecked there. Lonicera hirsuta Eaton and Ribes lacustris (Pers.) Poir. were frequent. A large bunch of Ribes prostratum L'Her was noticed on Sugar Island and at North Point Vaccinium canadense Kalm. At the upper end and on the west side of Thunder Bay Island were found Carex setifolia (Dew.) Britton, C. sartwellii Dew., C. crawei Dew., C. lanuginosa Michx., C. scirpoidea Michx., C. aurea Nutt., C. aquatilis Nutt., C. capillaris L., and C. marcida Boott., the last perhaps new to the state. Triglochin maritima L. was frequent. In the most shady parts were found a few specimens of Lycopodium annotinum L., L. obscurum L., Calypso bulbosa (L.) Oakes, Corallorhiza corallorhiza (L.) Karst., and Trillium cernuum L. More in the open fine specimens of Corallorhiza striata Lindl. were frequent. Iris lacustris Nutt. in damp places on the island and at North Point, just coming into bloom, covered the ground. Fragaria canadensis Michx. and Primula farinosa L. were common, the latter just going out of bloom. Houstonia ciliolata Torr. was plentiful in open grassy places. At the north end along the edges of slightly projecting lime rock, and about little pools of water, where the rising waves often cover the rocky shore, was noticed the slimy-leaved Pinguicula vulgaris L., its first appearance reminding one of a violet. On the west side in rich shaded ground were noticed in abundance small specimens of Washingtonia divaricata Britton, new I think to the state. At North Point growing on sandy ridges, were found thrifty and abundant specimens in one place of Adlumia fungosa (Ait.) Greene, Capnoides aurea (Willd.) Kuntze, and Leucophyllis grandiflora (Hook.) Rydb. Anemone hudsoniana Richards, Coreopsis lanceolata L., Rubus odoratus L., Arabis holboellii Hornem. and Quercus rubra were common on sand ridges.

There seems yet to be ample room for botanical research in that part of Michigan.

Received for publication, April 4, 1908. C. K. Dodge.

PROBLEM OF THE CAUSES OF THE FORMATION OF MECHANICAL TISSUE IN PLANTS.

It is quite generally believed by botanists that the woody, supporting tissue which a plant forms comes into being largely through hereditary influence. Considerable study has been made of the possible influence of external factors also. It has been found that an increase of transpiration of water increases the mechanical tissues; that in some plants, leaf-development and shoot-development cause an increase of mechanical tissue, even before leaf and shoot are mature enough to become functional. The various tensions which a tree trunk and root must undergo in swaying in the wind, in supporting their own weight, in supporting the weight of fruit, etc., are popularly supposed to induce the formation of supporting tissue.

Seventeen years ago, a number of experiments were made which seemed to show that longitudinal traction of stems of seedlings and stems of leaves brought a quick development of mechanical tissue. A repetition of those experiments more recently seemed to show that traction induced generally no increase of strength in the plant members.

This was the condition of the subject when the question was taken up several years ago in the botanical department of this University for careful testing. The reports by those who follow me on the program will show that longitudinal traction of stems, roots, and tendrils brings an increase of mechanical tissue, though not a remarkably large increase, and that swaying in the wind produces a large increase of mechanical tissue in stems.

FREDERICK C. NEWCOMBE.

THE INFLUENCE OF TENSION BY PULL ON THE FORMATION OF MECHANICAL TISSUE IN THE STEMS OF PLANTS.

JOHN S. BORDNER.

In as much as this paper will appear in full elsewhere, it will be sufficient to give here an abstract only.

Purpose: It was my purpose to add further and more conclusive experimental evidence to the knowledge of the reaction of actively growing stems to tension by pull along their longitudinal axis. To this end, 135 stems subjected to tension and as many controls, were tested at the end of experimental periods, for their breaking strength. An anatomical study of the most of these stems was also made.

Methods: Tension was applied to the experimental stems by means of a fastening on the stem, from which strong cords were run over a light running pulley, suspended directly over the plant. Weights were then attached to the free ends of the cord. The stems were broken at the end of the experimental period by pull along their longitudinal axes. This was accomplished by means of an apparatus constructed for this purpose. The amount of xylem, and of hard bast was measured by means of a projection apparatus and a polar planimeter; also by means of an ocular micrometer, and by camera lucida drawings, which were made on standardized bristol board. These drawings were then carefully cut out and weighed on a chemical balance.

Results: Stems of Helianthus annuus, Sinapsis alba, Phaseolus vulgaris, Ricinus communis, Vicia faba and Vinca major subjected to tension showed a higher breaking strength than did like stems used as controls. This increase over the breaking strength of the control varied from 5 to 55 per cent for different experiments. In every case, there was also an increase of xylem or of hard bast and in most species of both.

Rubus occidentalis and Lupinus albus stems were also experimented upon. The former showed an increase of hard bast but a decrease of xylem in the experimental stems as compared with the controls, and the latter, an increase of both these mechanical tissues. The breaking strength of these stems was not determined.

Botanical Laboratory of the University of Michigan.

THE INFLUENCE OF CONTACT AND TENSION UPON THE TENDRILS OF PASSIFLORA CAERULEA.

W. D. Brush.

The present paper contains a brief sketch of a part of the experimental work upon tendrils carried on by the writer during the past two years. This investigation was undertaken to determine the effect of contact and tension upon the strength of tendrils. Special care was taken to secure proper methods of comparison since the factor of individual variation must be taken into consideration in such work.

Experiments were first conducted to determine the effect of contact alone and of tension added. From these experiments the breaking strengths were found to be in about the following proportions:

Free tendrils...........................	245	grams.
Tendrils with contact alone...............	732	"
Tendrils with tension added (20 g.)........	1031	"

These results show that contact has a marked effect in producing greater strength in the tendril; however, of the effect of tension we cannot tell from these experiments, since the increase in strength with tension may be due to a greater contact and pressure stimulus.

This contact stimulus was eliminated in other experiments by applying tension to the tendril by means of ligatures so that in the experimental a certain region was under tension while in the control the corresponding region was not under tension while the contact was practically the same in each case. In these experiments an increase of nearly 50% was found in those under tension, showing that tension as well as contact has a marked effect in giving strength to the tendril. Other experiments have shown that increased contact pressure produces greater strength in the tendril, though increased contact through tension is found to play only a very small part in giving increased strength to the tendril in nature.

Marked anatomical differences are found in the tendril due to contact and to tension, but of these we will not treat in this brief summary.

To sum up the results of this work it was found that contact has a decided effect upon giving strength to the tendril, and by the addition of tension a still greater strength is obtained—each factor having a characteristic effect upon the anatomical structure of the mechanical system.

A full treatment of this work is to be published later.

Botanical Laboratory, University of Michigan.

EFFECT OF SWAYING BY THE WIND ON THE FORMATION OF MECHANICAL TISSUE.

(ABSTRACT.)

Experiments were carried on in the University greenhouse during the year 1906-1907 to determine the effect of swaying on the formation of mechanical tissue in normally erect plants. The apparatus was run by an electric motor, the motion being constant and regular, and the plants being swayed as by the wind back and forth in the same plane. Other plants were put in a rocking shelf, run by the same motor, and the whole plant was made to rock back and forth, the stems being supported by rods thrust into the ground. Control plants subject to the same conditions of light, heat, moisture, etc., were set up with those experimented on. A variety of plants were used in the course of the experiments, but the common garden sunflower, *Helianthus annuus*, proved most satisfactory.

Various measurements and tests, also microscopic examinations, were made, and a brief summary of the results obtained will be given here. In series C, for example, after nine days swaying, the averages obtained were as follows: height, experimental plants, 29.2 cm., control plants, 36.8 cm.; diameter in plane of swaying, 8.3 mm., excess over the transverse diameter, .99 mm., diameter of controls, 5.7 mm.

Conclusions: 1. Stems of plants swayed as by the wind are shorter and thicker than those not swayed.

2. The diameter in the plane of swaying is greater than that at right angles.

3. The xylem in the plane of swaying is greater than that in the transverse plane.

4. A greater amount of xylem is produced than in stems of controls.

5. The rigidity of the stems is increased by the motion.

6. This rigidity is greater in the diameter in the plane of swaying than in the transverse diameter.

7. The tensile strength is decreased, apparently, though the work on this point is not conclusive.

8. Rocking without tension produces some excentricity, due to geotropism.

9. Swaying "in the wind" produces greater excentricity, due to the combined stimulus of strain and gravitation.

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MYCORHIZÆ ON MICHIGAN TREES.

(ABSTRACT.)

The study of mycorhizæ was taken up by the writers in the fall of 1907. During the fall, before the ground became frozen, specimens of the roots of nearly all the forest trees in the vicinity of Ann Arbor were obtained and note taken of the occurrence of mycorhizæ as nearly as could be ascertained by superficial examination. Later in the year sections of acid fixed portions of the roots were cut and stained with anilin, safranin, methyl blue and by Gram's method. These sections were studied under the microscope and the presence and character of the mycorhiza determined.

Out of the 26 species of forest tree roots which were collected and microscopically examined, 16 were found to be ectotropically mycorhizal, 7 to be endotropically mycorhizal and three to be apparently free from any fungal affection. The ectotrophic species were the red, white and black oak, the tamarack, the Norway pine, the chestnut, the American elm, the mockernut and bitternut hickories, the beech, the blue beech, the ironwood, the black cherry, the trembling aspen, the poplar (Populus grandidentata) and the paper bark birch (Betula papyrifera.)

The endotrophic species were the swamp and sugar maple, the bass wood, the horse chestnut, the walnut, the butternut and the sycamore. Those that showed no mycorhiza as far as we were able to determine were the ashes, black and white, and the willow, while a merely superficial examination of the tulip tree, Ailanthus glandulosa and the papaw would seem to indicate that they too were unaffected.

G. A. DUTHIE,
D. M. MATTHEWS.

MYCORHIZA-PRODUCING BASIDIOMYCETES.*

L. H. Pennington.

A review of the recent literature shows that considerable attention has been paid to endotrophic mycorhiza. At the same time very little has been done with the so-called ectotrophic mycorhiza. This condition is probably due to the fact that in the case of endotrophic mycorhiza, the entire fungus is within the root and may possibly be isolated and studied by itself, while in the ectotrophic relationship the fungus is an unknown and uncertain factor. Any observations, therefore, which reveal the identity of fungi which enter into mycorhizal relations with higher plants is of interest and importance in the study of mycorhiza problems.

The fungi which have been found to produce mycorhiza upon the roots of trees belong with few exceptions to the Basidiomycetes. Rees (1) first called attention to the connection of Elaphomyces with the ectotrophic mycorhiza of forest trees. Noack (2) then followed with some observations in which he showed that the mycelia of *Geaster fornicatus* Fr. and *Geaster fimbriatus* Fr. are connected with the mycorhiza of pines. This discovery led him to further search until he established a mycorhizal relation in the following instances: *Tricholoma russula* Schaef. with beech roots, *Tricholoma terreus* Schaef. with pine and beech, *Lactarius piperatus* Fr. with Fagus sylvaticus and Quercus pedunculata, *Lactarius valerius* with beech, *Cortinarius collisteus* Fr. with pines, *Cortinarius caerulescens* Schaef. with beech, and *Cortinarius fulmineus* Fr. with oák. Woronin (3) merely suggested that some Boleti might be connected with the mycorhiza of trees. No other observers entered this field until Kauffman (4) showed the connection of *Cortinarius rubipes* Kauff. with three forest symbionts. The observavations given below may be considered as a continuation of the work begun by Dr. Kauffman.

During the summer of 1907, the writer had occasion to spend considerable time collecting fleshy fungi in the vicinity of Ann Arbor. On July 25, while collecting with Mr. J. S. Bordner in the woodlots west of Whitmore Lake, many specimens of *Russula emetica* Fr. were found growing in the rotten wood of much decayed logs. We noticed that every time we dug up a sporophore we also exposed mycorhiza structures upon a certain kind of rootlets Young sporophores were found within a few millimeters of mycorhiza structures, and the fine mycelium which is found converging at the base of a mushroom stem was found surrounding and apparently connected with these mycorhiza structures. Further search showed that the same conditions held true in every instance where this Russula was found growing in rotten logs. In similar situations where the Russula was not found, mycorhiza structures were not always found. The mycelium of this Russula was always found associated with the mycorhiza of one kind of roots only, which were found to be of the Red Oak. The decayed logs in which the Russula grew were in some instances identified as Red Oak also.

A few days later in the same woodlot, I found another form of *Russula*

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emetica growing in the soil. The mycelium of this fungus also was in every instance associated with the mycorhiza structures of Red Oak roots.

Some of the mycorhiza structures from Red Oak rootlets were imbedded in paraffine and sectioned. When cut thin and stained with gentian-violet, they present almost exactly the same appearance as those figured by Noack. The rootlet is surrounded as by a felt of mycelium, whose fine strands extend as a network down between the outer palisade-like cells.

After making these discoveries we paid more attention to mycorhiza, both to confirm our first observations and to determine whether other species form mycorhiza. Although mycorhiza structures were frequently found near the sporophores of various species, it cannot be said with any degree of certainty that there was any connection. It is very difficult to follow fine white mycelia through the soil, and since many kinds of mycelia may be found in close proximity, it is easy to mistake one for another. Special attention was paid to the *Russula emetica* which is found in swamps, but it is not yet determined whether this form is a mycorhiza producer or not. When, however, the fungus mycelium is colored the problem is not so difficult.

Among the numerous specimens which were collected in a small oak-hickory grove within the city limits, was a handsome Boletus, which we identified as *Boletus speciosus* Frost. The stem of this Boletus is of a bright yellow color within, a fact which suggested that its mycelium might be yellow also. Accordingly I returned to the place where the specimens were collected, and found some more of the same kind. As soon as I dug into the ground, after removing the sporophore, I found the bright yellow mycelium running through the soil in all directions and extending down to the subsoil. Some of the mycelial strands, which resembled rhizomorphs, were as much as a millimeter in diameter. Some of them were within dead roots whose cortex alone was still intact, and some followed the course of live roots and sent out branches, which were plainly connected with mycorhiza structures upon the rootlets. The fungus thus appears to be both a saprophyte and a symbiont, if we allow that mycorhiza form a symbiotic relationship. The mycorhiza structures in this instance were yellow corresponding to the yellow mycelium. Nine sporophores of this Boletus were found within an area having a diameter of about three rods. For every one, the yellow mycelial strands were found associated with the same kind of mycorhiza structures upon the same kind of roots. In October when we returned to follow up some of the roots in order to determine to what tree they belonged, we found more of the mycelial strands connected with mycorhiza structures upon the rootlets. Some of these strands were also connected with small yellow sclerotia down near the subsoil. These sclerotia were from one to three millimeters in diameter and sometimes as much as eight millimeters long. Cross sections of the larger specimens show practically the same cellular like structure as those figured by DeBary (5) and Léveillé (6). The smaller and younger specimens appear to be composed of a dense mass of interwoven hyphae very similar to those which are described and figured by Brefeld (7) for Coprinus stercorarius Fr.

On October 2, Dr. Kauffman found a Cortinarius (species not yet determined) with a yellow mycelium, which was connected with the mycorhiza of Red Oak roots.

The last fungus that we found producing mycorhiza was *Tricholoma transmutans* Pk. When some of the sporophores were dug up, younger stages were found just beneath the surface of the soil, all growing from a light yellow mycelium. The mycelial threads were very abundant and always

thickly clustered about the roots of the Black Oak. Upon the rootlets and connected with the mycelium were numerous ectotrophic mycorhiza structures.

There is little doubt that the three fungi with colored mycelia form mycorhiza with oak roots. Since, however, the mycelium of *Russula emetica* is white and very fine, and since the mycelia of nearly all fungi are white, there might be some question as to whether the mycorhiza was caused by the Russula or by some other fungus. As other agarics are now known to cause mycorhiza, it is quite possible that Russulas also may be mycorhiza producers. The mycelium of *Russula emetica* was so generally associated with the mycorhiza structures upon Red Oak roots that it is altogether probable that it may produce mycorhiza upon the Red Oak, at least, Many sporophores of several different Russulas were dug up. In no instance, however, was there any evidence that they were mycorhiza producers. It would be a remarkable coincidence if the mycorhiza of the Red Oak happened to be near sporophores of *Russula emetica* while scarcely any mycorhiza could be found near the sporophores of other species.

The occurrence of sclerotia in connection with *Boletus speciosus* Frost deserves notice, for up to the present time, no one seems to have reported a Boletus with sclerotia nor sclerotia connected with mycorhiza.

In conclusion it can be said that another *Cortinarius* and probably some forms of *Russula emetica* may produce mycorhiza upon the Red Oak, and that *Boletus speciosus* Frost and *Tricholoma transmutans* Pk. may produce mycorhiza upon the Black Oak.

LITERATURE CITED.

1. Rees, M., Uber den Parasitismus von Elaphomyces granulatus. Bot. Zeit. 38: 729. 1880.

——— Uber Elaphomyces und sonstige Wurzelpilze. Ber. Deutsch. Bot. Gesells. 3: 294. 1885.

2. Noack, Uber Mycorhizenbildende Pilze. Bot. Zeit. 47: 389. 1889.

3. Woronin, M., Über die Pilzwurzel von B. Frank. Ber. Deutsch. Bot. Gesells. 3: 205. 1885.

4. Kauffman, C. H., Cortinarius as a Mycorhiza-producing Fungus. Bot. Gaz. 42: 208. 1906.

5. DeBary, A., Vergleichende Morphology und Biology der Pilze, Mycetozoen, und Bacterien, 1884.

6. Léveillé, Memoir sur le Genre Sclerotium. Ann. Sc. Nat. 2e Serie, Tom. 20.

7. Brefeld, Botanische Untersuchungen 1-3, Tafel 2.

CAN FUSARIA ASSIMILATE ATMOSPHERIC NITROGEN?

L. H. PENNINGTON.

(ABSTRACT.)

During the spring and summer of 1907 several series of cultural experiments were made with a Fusarium (Fusarium zeae) to determine whether it is able to assimilate atmospheric nitrogen. Growth tests in many nutrient solutions and careful chemical analyses showed that this fungus cannot assimilate atmospheric nitrogen in solutions free from combined nitrogen nor in solutions containing combined nitrogen.

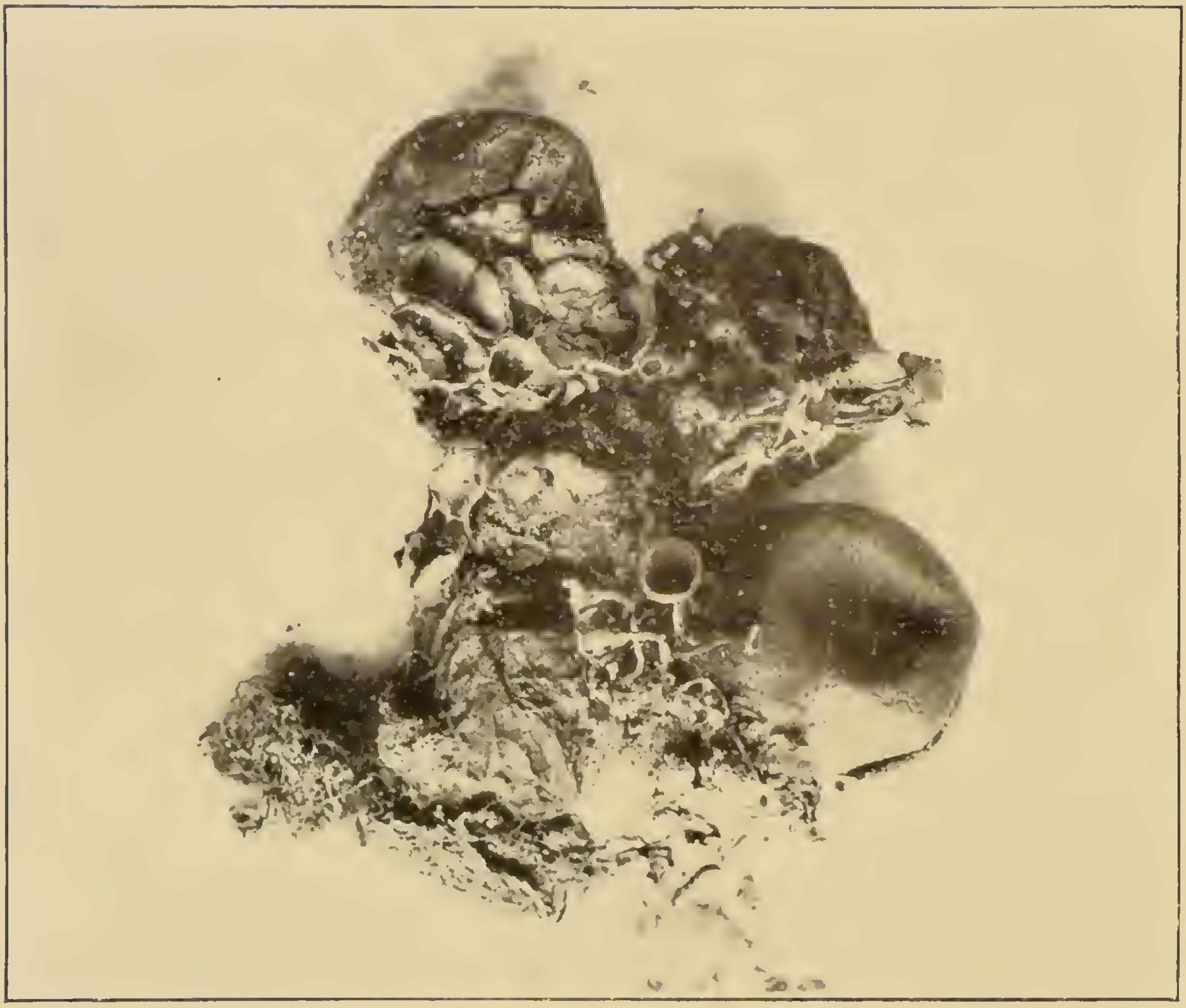


Figure I. shows the general habit of the fungus with the old plums attached —natural size. (Photo made by Prof. Pettit.)

FIGURE II.—Natural size, showing a wide variation in size of apothecia, one large one (a) about 1-5 cm across. See smaller ones above. (Photo made by Prof. Pettit.)

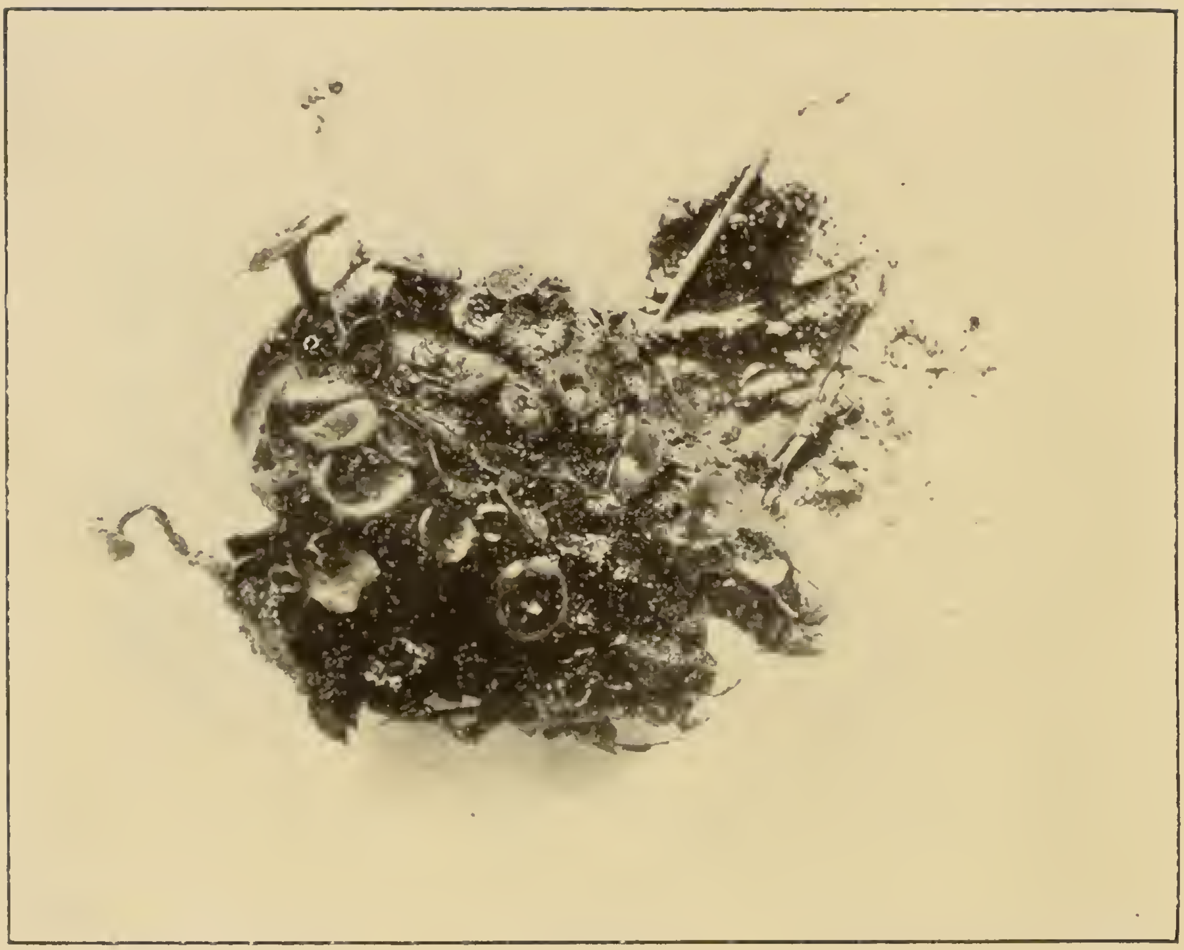


FIGURE III.—Illustrates a large number (perhaps 25) of apothecia from one plum. (Photo made by Prof. Pettit.)

WINTER STAGE OF SCLEROTINIA FRUCTIGENA.

J. B. Dandeno.

Monilia fructigena is one of the commonest of the rot-producing fungi. Almost any kind of fleshy fruit may be made to serve as a host, and inoculation is always easy. From inoculations made artificially, the conidial, or summer stage, is the only one produced. In fact, the name *Monilia* was given to this summer stage as though this were the whole plant, and not simply one phase of its existence. The genus *Sclerotinia* was also well known, but it was not known that there was any connection between *Monilia* and *Sclerotinia* until 1902, when J. B. S. Norton, in the Transactions of the Academy of Science of St. Louis described it, giving demonstrations showing that *Monilia* was only a summer, or conidial stage of a *Sclerotinia*. The discovery was a very important one, not only from a scientific point of view, but also from the economic side. The whole life history of a parasite being once known, the matter of checking it becomes an easier one. However, this fungus is such an extremely vigorous form that a winter stage is not nearly so necessary as for many other forms. Ungerminated spores may remain in a room for years and years, and then, when opportunity offers, germinate. So that, even though the winter stage be materially checked, the disease will likely occur from year to year, though doubtless much less extensively.

This winter stage, or *Sclerotinia* stage, as it is sometimes called, is the condition of the fungus to which particular reference is here made. Up to the present, so far as the writer is aware, there has been considerable difficulty in obtaining specimens for laboratory use; and because of the importance of the fungus from an economic point of view, laboratory material is especially desirable for students in horticulture. And if this winter stage were sufficiently abundant, there could be no better form for class illustration in morphology, to show one of the fungi imperfecti and in complete form. The *Monilia* stage is the fungus imperfectus, so-called, and this with the *Sclerotinia* stage, the complete form. Moreover, the *Sclerotinia* stage, which we might now call the ascus stage, is so very easy to see, and to manipulate, that it is especially desirable. The *Monilia* stage, which is the conidial stage, is so extremely abundant and hardy that there could be no better example for the use of the student. The only reason, therefore, why the plant has not found its way into university laboratories for class use is that the ascus stage was so extremely rare. But it is not rare; it is plentiful, if one knows where to find it. In the spring of 1907, a basketful, of which figures* I, II, and III, are samples, was collected in an area of two or three square yards. In 1906, a considerable quantity was obtained in the plowed ground under plum trees, but a large area had to be gone over, in order to obtain a few specimens.

In the fall of 1905 diseased plums affected abundantly with the conidial stage were "planted" in different places with a view toward obtaining plenty of material for laboratory study. Upon examination of this material, in

* These photographs were kindly made by Prof. Pettit from fresh material collected by the writer about May 10, 1907, in the college orchard.

the spring of 1906, the hopes which germinated the year before, were rudely killed. No success whatever had attended our effort, and no material result of value, either, excepting that a knowledge of how *not* to obtain the ascus stage was obtained.

Connecting the information gathered from this experiment with a study of the conditions surrounding those specimens obtained the year before, on the plowed ground under the trees, the suggestion arose that there was a right place, and wrong places, in which to look for material. The right place is in the surface of the ground, among dead, long grass around and near the foot of the tree. Of those found in the open, on the naked ground, it was observed that they were *not* on top of the soil, nor yet *under* ground, but half in and half out. On account of the fact that the old diseased fruit should be half in and half out of the ground, it is not frequently that specimens can be found on the open plowed ground, because rain, frost, and the like, render it very improbable that a fruit should be so situated the whole season. If underground, the fruits will rot; if above ground, they will dry out. But in sod, where the soil surface is not likely to be disturbed, and the old fruits are protected by the shelter of the grass, is the place where the ascus stage flourishes.

From such well-sheltered plums, abundant material was obtained. The apothecia grow on ascophores two or three centimeters long, and develop from the underside of the old plum, turning up around the side and assuming the erect form. At first, these apothecia and ascophores are nearly cylindrical structures, but later, the end of the ascophore opens, and the well-known disk appears. These disks are sometimes as much as a centimeter across (see figure II. a) and often ten or fifteen grow from a diseased plum (see figure III.) In these apothecia are many thousands of asci and in each ascus eight spores. In one case, an estimate was made as to the number of asci in one of these apothecia, and it was found that there was probably not less than ten million. This would give eighty million spores produced from one old plum. From this it may easily be inferred that under a single plum tree, or on a few square feet, there might be spores enough to infest a whole orchard.

I might say that I have never found specimens of peach fruits affected with the *Sclerotina*, partly because in the vicinity of East Lansing, few peaches are grown. I presume, however, that where peaches are grown, and where *Monilia* is common, there will be plenty of material.

The supplying of laboratory material for study has been kept in mind, because of the suitability of it for student study, but another important deduction might be made from the investigation.

In view of the fact that this fungus has such a well-developed and vigorous winter stage, and in view of the fact that it is so destructive and so common in orchards, some little success might be expected to follow a vigorous and systematic plowing under, or otherwise destroying, the old affected fruits. Knowing that the ascus stage does not develop on old fruits which have been buried, it should be comparatively easy to get rid of the winter stage by turning down all the old fruits around the trees. As has been pointed out, it is also highly important that no grassy patches should be allowed to grow up around the base of the trees. As orchards are cultivated frequently by using horses, and as the plow can not be brought close enough to the tree to turn over all the soil, there is left a lens-shaped tuft with the tree as the center upon which the grass and weeds grow and form a splendid breeding place for the winter stage of this fungus.

Although this fungus is a vigorous one, and is capable of wintering over in the conidial stage, yet there is not the slightest doubt that considerable success would attend an active campaign against the winter stage. The orchard should be plowed in the fall, and what the plow does not reach, should be dug under by hand, thus getting all the old fruits underground where the fungus does not survive. But the question of cover crops arises, and to this it can be said that for the fungus the cover crops are very favorable. In fact this can be said in regard to several other injurious fungi. Plow them in if you wish to destroy them.

Agricultural College, April 3, 1908.

CAPILLARITY OF CELLULOSE.

J. B. Dandeno.

It should not be necessary to define such a common term as capillarity, but, in view of the fact that there are, in technical physics, at least, two meanings, distinct and even opposing, and in common language another more indefinite meaning, it is thought well to make ourselves perfectly clear. Some use the term capillarity to include attraction, and also surface tension. Others use it to mean a certain peculiar kind of attraction, or at least attraction between a solid of peculiar form, and a liquid. What is meant here by capillarity is that attraction which takes place at touching distances between a solid and a liquid. We employ capillarity, then, as a definite term, and, if we use it negatively, as well as positively, it is quite general in application. Capillarity, will, therefore, depend upon the nature of the solid and the liquid, with respect to the affinity of the one for the other; upon the affinity of the solid for air; upon the amount of mass of the solid, and upon its form, whether in flat sheets, fibers, or other masses.

The amount of capillary attraction will, therefore, depend upon several factors. In the case of cellulose which is one of the most baffling of chemical compounds, it is necessary to select one of the best known of the forms and concern ourselves with this alone.

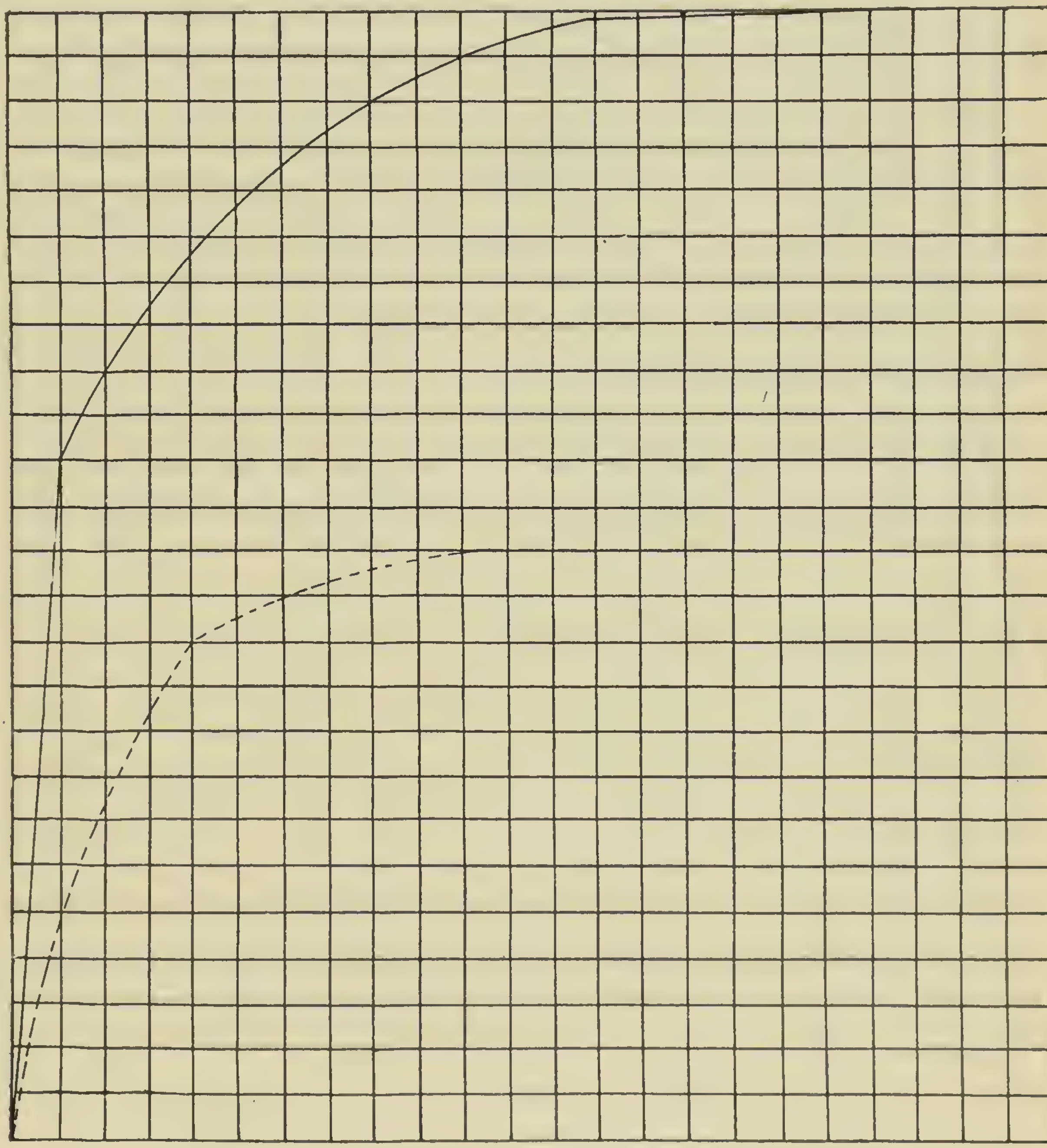
Swedish filter paper which is made of practically pure cotton, and which has been cleansed from all traces of oil or of substances of an oily nature, seems to be fairly well adapted to problems in capillarity. Raw cotton hairs are quite different from the cotton of filter paper, and also quite different from absorbent cotton. In fact, absorbent cotton becomes absorbent because of the capillarity of such cotton, and this capillary attraction is developed chiefly because the raw cotton has been treated with an alkali sufficiently strong to destroy all the oily matter ordinarily adherent to the hair. So that the capillarity of cotton fibre will depend upon the treatment to which raw cotton has been subjected in processes of manufacture.

Swedish filter paper is fairly uniform in composition and in capillary attraction, and it was found to be the most satisfactory form for the purpose. Its specific gravity is 1.13.

In order to test the force and the rapidity with which such fiber attracts water, an arrangement was made with glass tubes in which was a continuous strip of filter paper about 15 mm. wide, folded loosely and drawn into the glass tube. The object of having the paper surrounded with glass was to keep the air from coming into contact with the water while ascending in the tube. If strips of filter paper be exposed to the open air, it is quite clear that, at a certain point, the drying power of the air would be so great as to render it impossible to raise the liquid higher, even though the capillary attraction had not yet been satisfied. These glass tubes containing strips of filter paper being, on inside diameter, about five mm., were set up vertically with the lower end just immersed in the liquid which was being subjected to examination.

Various means were employed to determine at any given time just how high the ascending liquid had crept, but the simplest and easiest method

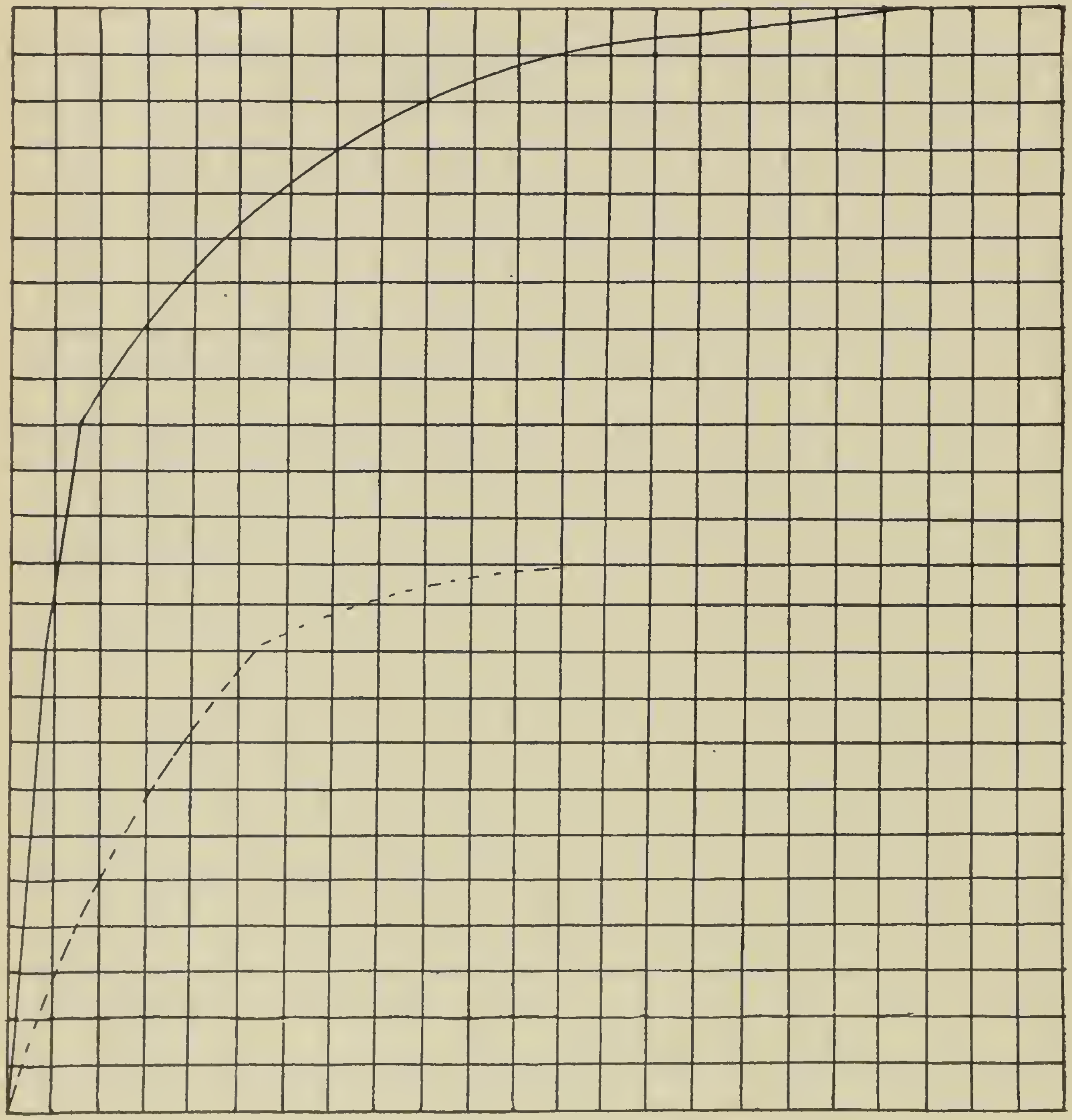
was to use dry filter paper. When the lower end of the tube was immersed in water, the water began to climb, and the highest point reached by the water was clearly indicated by the color—the wet appearance—of the filter paper. An interesting point was brought out with filter paper first made blue with litmus, and a weak solution of sulphuric acid used as the capillary liquid. The acid showed clearly its height at any given time by the reddening of the filter paper, but at the same time it could be readily seen that the acid and the water had separated in ascending—the water rising faster than the acid.



H_2O
K_4FeCy_6

The application of these separation phenomena has been thoroughly worked out by Frederick Goppelsroder, Basel, 1901. His work is exhaustive and is entitled Capillaranalyse Emporsteigen der Farbstoffe in den Pflanzen. Though Goppelsroder used some form of cellulose in his separation analyses, yet he did not determine for any one of his liquids or substances in solution the actual amount of capillary attraction.

Among the results obtained from the different sets of experiments here worked out, three are given as indicated in the accompanying curve. The water used was distilled, the acid one-fiftieth normal sulphuric, and the potass-ferro-cyanide one per cent. The figures forming the basis of these curves were obtained from a combination of several experiments, and not from one alone. In plotting the curve, the spaces measured vertically were made 3 cm., and the horizontal spaces each one day.



H_2O
H_2SO_4

From these results it might be inferred that the height to which water will ascend along the filter paper is about 75 cm., sulphuric acid 36 cm. and potass-ferro-cyanide 39 cm.

In discussing the subject of ascent of sap in plants, capillarity is usually given as one of the factors, and from this experiment it might be fairly concluded that, supposing the cellulose of the conducting vessels and the wood

cells of trees, is as great as that of Swedish filter paper, the importance of capillarity as a factor can not be of very high significance. But we have no proof that it is the same.

Commercial artificial silk does not possess nearly so strong a capillary attraction as does the filter paper here used.

What the experiments here described seem to prove is this: The capillary attraction of cellulose for water is of such an amount as to cause an ascent against the influence of gravitation, of 66 cm. vertically. That gravitation is a controlling factor was shown by the fact that, when the tubes were placed in a slanting position, the liquids rose to the same height and of course to a greater distance along the tubes. 75 cm. becomes one side of a right angled triangle, the height of tube the hypothenuse, and the horizontal distance the other side of the triangle.

As cellulose in some form is one of the most important substances known to man to-day, it is worthy of minute investigation from every point of view.

Agricultural College April 3, 1908.

ON THE TOXIC ACTION OF BORDEAUX MIXTURE AND OF CERTAIN SOLUTIONS ON SPORES OF FUNGI.

J. B. Dandeno.

The spores of a fungus are usually by far the most resistant portions of the fungus-plant, not only to poisons, but also to various other injurious factors of environment. And, as might be expected, the spores of one species may differ in resisting power, very materially, from those of another species. So that it can scarcely be predicted what will happen in one case from what happens in another.

The objects of the experiments here described were to determine the resisting power of some of the common forms of fungi to certain toxic solutions, and also to Bordeaux mixture, seeing that Bordeaux mixture is a substance so commonly used as a remedy for plant diseases.

The species made use of were *Penicilium glaucum, Puccinia asparagi, Macrosporium nobile, Ustilago maydis, Glomerella rufomaculans* (Bitter rot). The toxic substances employed were NaOH, KOH, HCl, H_2SO_4, $CuSO_4$, and Bordeaux mixture. In all these substances, excepting the last, fractions of normal solutions, as indicated in each case, were taken. In $CuSO_4$, water of crystallization, and the fact that it is dibasic, were of course taken into consideration. The method employed to test germination was simple and certain. A drop of the solution was put upon a slide, and in this drop were placed spores of the fungus which were to be tested. This preparation was then set away in a moist chamber to prevent evaporation, and left there. The slides were then examined from time to time and records made. The test was, therefore, as to whether the spore was able to germinate and send out a hypha while actually immersed in the liquid. If the spore germinated, it seemed conclusive proof that the fungus could tolerate this poison, more particularly because the first hypha sent out by the spore is very sensitive. The spore itself, being usually very resistant because of its thick wall, and other qualities, might easily withstand much stronger solutions than those used, especially if the spores happen to be in a dormant state. But it was the mycelium, and not the spore, that was tested.

As Bordeaux mixture is composed of a liquid and of a solid (in very small particles), two conditions require attention, (1) the liquid without the solid, (2) the solid and liquid mixed. The latter is, of course, the form used in spraying for fungus diseases.

The Bordeaux mixture was prepared from the general formula, 4 lbs. crystalline copper sulfate, 4 lbs. fresh lime, and 40 gallons water. It was found, however, that much more lime than this was required to neutralize the copper in the solution, so that in the supernatant liquid, when treated with potass-ferro-cyanide, no reaction resulted. The Bordeaux mixture actually used contained approximately 6 lbs. lime, 4 lbs. copper sulfate, and 40 gallons water. The strongest solution employed in these tests was a double strength of Bordeaux, i. e., 6 lbs. lime, 4 lbs. copper sulfate, and 20 gallons water, and from this stock the following grades of dilution were made:—2, 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$. The first here

mentioned was the stock solution and the second the actual Bordeaux prepared as indicated above.

From the experiments with Bordeaux mixture, two sets of experiments were worked out, with (1) the mixture well shaken up (2) the supernatant liquor, without any precipitate.

As the ordinary user of Bordeaux mixture or of copper sulfate would not be likely to interpret readily what is meant by a normal solution, and, as the method usually employed in making up solutions of copper sulfate or other substance, is to reckon it in percentage strength, a list is here given showing the relation between percentage solutions and normal solutions.

Of copper sulfate crystals	normal	solution	=12.5%
1/2	"	"	= 6.25%
1/4	"	"	= 3.125%
1/8	"	"	= 1.5625%
1/1024	"	"	= .012%

Of dehydrated copper sulfate a	normal	solution	= 8.05%
1/2	"	"	= 4.025%

As a matter of course, the normal solutions are the same in each case, that is, they contain the same actual amount of copper sulfate to a given amount of water, but where crystalline sulfate is used, the amount of water of crystallization which is approximately 36 per cent by weight of the sulfate, has to be taken into account.

In the following tables, is given in each case the name of the toxic agent and, in the first horizontal column, the strength of solution used. In this column, for convenience only, the denominator of the fractional normal solution is placed; that is, 256 means n/256, etc. Only the name of the genus of fungus is given in the first vertical column, but the name o' the species has already been stated, so need not be repeated. In the other columns, the letters indicate:—*G* germinated certainly; *S* slightly, or only very small in amount; *O* no germination whatever. Where a question mark occurs, it means that repeated experiments did not agree.

I. HCl.

	8	16	32	42	64	128	256
Penicilium	O	S	G	G	G	G	.....
Macrosporium	....	O	O	S	G	G	.....
Ustilago	S	G	G	G	G	....	.....
Puccinia	....	....	....	....	O	O	G
Glomerella	....	....	....	O	O	G	G

II. H_2SO_4.

	8	16	32	42	64	128	256
Penicilium	O	(?) O	S	G	G	G	....
Macrosporium	....	O	S	G	G	G	....
Ustilago	O	S	G	G	G	G	.....

III. $CuSO_4$.

	128	256	512	1024	2048
Macrosporium	O	S	G	G	....
Ustila o	....	S	G	G	....
Glomerella	....	O	O	S	G

IV. NaOH.

	8	16	32	64
Macrosporium	O	G	G	G
Puccinia	S	G	G	G
Ustilago	O	S	G	G

V. KOH.

	8	12	16	32	64
Macrosporium	O	S	G	G	G
Puccinia	O	O	S	G	G
Ustilago	O	O	S	G	G

VI. BORDEAUX MIXTURE (WHOLE.)

	2	1	½	¼	⅛	1–16
Ustilago	S	G	O	O	G	G
Macrosporium	....	S	G	S	(?) O	S
Glomerella	....	O	O	O	O	O

VII. BORDEAUX (SUPERNATANT LIQUID ALONE.)

	2	1	½	¼	⅛	1–16
Ustilago	(?) G	G	G	G	G	G
Macrosporium	S	G	G	G	G	G
Glomerella	O	S	G	S	O	O

From the results set forth in table I., and table II., we find HCl more toxic to *Macrosporium* than H_2SO_4, but the reverse appears to be the case with *Ustilago*. It is quite clear also that the different fungi differ among themselves materially in resisting power. In table II., notice *Ustilago* germinating in HCl at a strength of n/16, while *Glomerella* requires a dilution of n/128.

In looking at table III. it is quite worthy of remarking the high concentration of solution of $CuSO_4$, that these fungi will resist, especially *Ustilago* and *Macrosporium*. This remarkable resisting power to toxic solutions becomes very apparent when we compare radicles of seedlings with these fungus hyphae. Corn radicles are just able to withstand a concentration

of HCl, in quantities of 25cc, n/16384 (Dandeno, Am. Jour. Sci., 17 June, 1904, p. 455.), but die in a solution of n/8192. Lupines are about the same. For $CuSO_4$, corn *just* lives in a concentration of n/524288, and dies at the next stronger concentration. Lupines are more resistant than corn to $CuSO_4$, Lupines (the radicles) can survive a concentration (25cc) of n/65536, but die in the next stronger. If we arrange the three fungi *Ustilago*, *Macrosporium*, and *Glomerella* with corn, lupine and pea radicles to show the relative resisting power (1) against HCl we get: *Ustilago*, 1024, *Macrosporium* 256, *Glomerella* 128, corn 2, lupine 1, pea 1. This means that *Ustilago* resists a solution of HCl 1024 times as concentrated as the lupine or the pea. (2) With regard to $CuSO_4$, the following figures appear. *Ustilago* 1024, *Macrosporium* 1024, *Glomerella* 256, lupine 8, pea 2, corn 1. The figures for corn, lupines and pea are taken from a table on page 455 in the paper already cited (Am. Jour. Sci. 1904.)

The cells of the radicles of the seed plants just mentioned are probably not very different from living cells of the mesophyl of the leaves, so that when the problem of spraying is under consideration, it should not be forgotten that the fungus which it is desirable to destroy, is much more, very much more, resistant than the living, sub-epidermal cells of the leaves. But the cutin, trichomes, wax, oil or other substance on the surfaces of leaves, protect the living cells within the leaves, so that it is possible to use a spray liquor sufficiently toxic to destroy the fungus, and yet not seriously injure the leaf.

In preparing and examining the numerous slides required in the experiment, it was found that small particles of dust, or of other matter which might be deposited on the slide with the spores to be tested, affected often quite seriously the solution. The spores which happened to be within the neighborhood of such foreign particles, or clusters of particles, survived the solution, while others on the same slide did not. These substances simply reduced the toxic action, by physical affinity, of the solution. But this is not surprising in view of the experiment of Ruby Fitch (Annales Mycologici IV, 4, 1906), who showed that sand, glass, broken pottery and other substances reduced very materially, under certain conditions, the toxic activity of the solution.

Similar results were obtained by the writer (l. c.) with radicles of corn, pea and lupine. It was found in those experiments that pure sand, when added to the toxic solution, reduced the toxic activity in some cases as much as 128 times. This means that, when sand is present, 128 times as much $CuSO_4$ might also be present without any further injurious effect.

From these experiments, two points of some importance in laboratory work were made. (1) Corn smut does not germinate very readily until January or February following the harvesting of the corn crop. The brand spores seem to require a resting period. (2) Hydrochloric acid, about n/128, or copper sulfate, n/2048, furnish excellent media in which to produce sporidia from the brand spores. In these liquids, the spores germinate much better than in tap water, distilled water, or manure decoction. Moreover, HCl, and $CuSO_4$, on account of their toxic action, check the growth of an enormous number of things which would be likely to appear in water or manure liquor. They act as a sort of a medicine to the preparation.

The experiment with KOH and NaOH did not show any result which seemed of very great importance. KOH is undoubtedly more toxic than NaOH. The same is true with radicles of pea and of lupine. If these be arranged with the fungi in order of resisting power against KOH (25 cc.) we

get, *Puccinia* 8, *Macrosporium* 8, *Ustilago* 4, corn 2, lupine 1, pea 1. With these solutions, there is a similar difference, but not nearly so great as with the acids or with copper sulfate. Puccinia resists therefore, 8 times as much as the pea of KOH.

In table VI., there is one rather peculiar result. Corn smut survives in the solution at full strength, and perhaps, to some extent, in double strength; but it cannot survive one-half or one-fourth strength. *Macrosporium* is not quite so resistant as corn smut but grows readily in one-half strength. It, like the smut, does not grow in a solution one or two grades more dilute. *Glomerella* did not grow in any of the solutions tried. At first glance it appears as though the table presented a paradox. But this might be explained on the ground that, in the strong solutions, crystalline bodies were formed, and by this, the toxic action was reduced. When more dilute, the crystal bodies were not formed so extensively, hence the toxic action of the solution would not be so materially affected. In still more dilute mixtures, the fungi were able simply to withstand the poison when at this dilution.

Table VII. presents a similar result to that of VI. But the peculiar part of it is, that this should be toxic at all. There is no soluble copper in it as shown by the test with potass-ferro-cyanide. There should be nothing in the liquor but calcium in some compound or other; but calcium is scarcely toxic, at even very great concentration to radicles of seed plants, and should be much less toxic, reasoning from the experiments described in this paper, to fungi. That the liquor is toxic to fungus hyphae is shown especially with *Glomerella* as it is toxic at even 1/16 strength. The liquor is also toxic at double strength to *Ustilago* and *Macrosporium*.

This Bordeaux liquor problem needs further investigation, both physiologically and chemically. From the fact that both tables VI. and VII. are similar in respect to the paradox just mentioned, it might reasonably be inferred that the liquor part, as well as the solid parts play some rôle in the action of Bordeaux mixture as a fungicide.

Agricultural College, April 4, 1908.

UNREPORTED MICHIGAN FUNGI FOR 1907, WITH AN OUTLINE OF THE GASTEROMYCETES OF THE STATE. *

C. H. Kauffman.

During the past season an effort was made to obtain as complete a knowledge as possible of the mushrooms growing within reach of Ann Arbor. The weather conditions at Ann Arbor were so favorable to the development of these fungi that the material obtained was little short of overwhelming; so that it is possible to add over a hundred species to our state Flora. Several excursions were made into the neighboring counties, but the wealth of forms which appeared at home, forbade the wasting of any time on unfamiliar localities. The experience of former years had seemed to show a scarcity of species in this region, supposedly because of the lack of extensive forests and the effect of keeping woodlots free from logs and debris and using them for pasture. These are still to be considered important influences on distribution. When, however, the effect of thus removing the moisture-holding substances from the woods is overcome by a sufficiently abundant and continuous rainfall, the mycelium, which still seems to hold its own in these places, suddenly becomes vigorous and fruit-bodies spring up in surprising quantities. Even then, however, there is a decided local distribution. Oak openings with the proper amount of ground moisture were teeming with Boleti and Russulae in the middle of summer; wooded hillsides with tiny rivulets seeping through their sides were literally covered in spots with Cortinarii. The forms which grow on rotten wood, attained their best development in low swampy woods in which debris had been allowed to accumulate. Many low woodlots in which cattle were kept were almost without any mycologic flora of the mushroom type, as were also such as had too rank a covering of grass.

The paper is composed of two sections: First, the list of unreported fungi; second, a preliminary outline of the puff ball group.

A more extended notice of all the Basidiomycetes collected will be given in the report to the State Geological and Biological Survey under whose auspices the work was continued.

My thanks are due to Prof. G. F. Atkinson and Prof. C. H. Peck for various determinations referred to in the text. Dr. E. J. Durand kindly examined some of the Discomycetes. I am also under obligations to some of my students for specimens collected by them.

ASCOMYCETES.

Pezizaceae.

Barlaeina miniata (Cr.) Sacc. Ground in Woods. Washt. Co. May 8, fide Durand. (Syn. Plicariella miniata.)

Geopyxis carbonaria (A. and S.) Durand. Washt. Co. fide Durand.

Lachnea setosa Nees. On rotten logs. Washt. Co., Nov. 9, fide C. H. K.

Peziza orthotrica B. and C. On ground among Polytrichum. Washt. Co. fide C. H. K.

*Contribution No. 97 from the Botanical Department of the University of Michigan.

Peziza vesiculosa Bull. Washt. Co. fide C. H. K.
Sphaerospora hinnulea (Br.) Washt. Co. fide Durand.

Ascobolaceae.

Lasiobolus equinus (Mull.) Karst. On horse dung. Washt. Co., fide C. H. K.

Helotiaceae.

Chlorosplenium aeruginascens (Nyl.) Karst. On rotten wood. Washt. Co., Nov. 9, fide C. H. K.

Dasyscypha Agassizii (B. and C.) Sacc. "Originally discovered on the north shore of Lake Superior." Houghton, Mich. Aug. 1906. fide Durand.

Onygenaceae.

Onygena equina Pers. On decaying horns of cattle, in woods. Autumn, Washt. Co., fide C. H. K.

Elaphomycetaceae.

Elaphomyces variegatus Vitt. At base of a Crataegus trunk. Washt. Co. Cascade Glen. legit C. H. K.

Eutuberaceae.

Tuber Lyoni Butters. Low swampy woods, 7 miles west of Ann Arbor. Washt. Co. Sept., legit C. H. K.

Hysteriaceae.

Glonium stellatum Muhl. On rotten wood. Washt. Co., Nov. 9, fide C. H. K.

Hypocreaceae.

Hypocrea stereorum (Schw.) B. and C. On Sp. of Stereum. Washt. Co., Nov. 2, fide C. H. K.

Sphaeriaceae.

Rosellinia rhodomela (Schw. and Cooke.) On rotten wood. Washt. Co., Nov. 9, fide C. H. K.

BASIDIOMYCETES.

Hypochnaceae.

Hypochnus Sambuci (Pers.) Fr. On rotten limbs. Washt. Co., Nov. 4, fide C. H. K.

Clavariaceae.

Physalacria inflata Pk. On wood. Washt. Co., fide C. H. K.

Hydnaceae.

Hydnum albonigrum Pk. (Syn. Phellodon alboniger (Pk.) Banker.) In low woods. Washt. Co., Oct. 4, fide Pk.

Hydnum concrescens Pers. (Syn. Hydnellum concrescens (Pers.) Banker.) Ground in woods. Washt. Co., Oct., fide C. H. K.

Sistotrema confluens (Pers.) (Syn. Hydnum sublamellosum Bull. per Banker.) Ground in woods. Washt. Co., Sept., fide C. H. K.

Polyporaceae.

Boletus bicolor Pk. Open oak grove. Washt. Co., July 22, fide C. H. K.
Boletus speciosus Pk. Oak openings. Washt. Co., Aug. 12, fide C. H. K.
Boletus sphoerosporus Pk. Grassy ground, cemetery. Washt. Co., July 21, fide C. H. K.

Fomes fraxineus Fr. In low woods. Whitmore Lake, Washt. Co., Oct. 10, 1906 and Oct. 20, 1907. Mr. L. H. Pennington collected it on the same Ash stump in two successive seasons. Mr. C. G. Lloyd, Prof. Peck and Dr. Farlow all consider it identical with the European species. When young it shows the reddish color referred to in the descrip-

tion of the species; this color is lost more or less in age. The query arises, could it have been introduced from England in some unaccountable way by the English settlers of Mich.? Prof. Peck says Schweinitz reports it, but he thinks it likely that Fomes fraxinophilus Pk. may have been the plant which Schweinitz saw. Murrill reports it from Ohio, Illinois, New York and Louisiana.

Fomes fraxinophilus Pk. On Ash trunks. Washt. Co., April 19, fide Pk.

Fomitiporella Johnsoniana Murrill. "Type collected at Ann Arbor, Mich., on rotten deciduous logs, Sept. 8, 1894." This is described as a new species by Murrill from material he found in the New York Botanical Garden. It belongs to the old genus Poria, and has a brown, stratified plant body and brown spores. He separates it from Poria inermis, to which it seems very close, by its thick-walled tubes.

Polyporus griseus Pk. On the ground in low woods, Wayne Co., Sept. 5, fide Pk. This has hitherto not been reported west of New York. I found it on two successive summers in the same woods. It is easily known by its central stem, lilac to ashy or pale gray color, and rather soft context.

Polyporus caesius (Schrad.) Fr. On rotting logs, probably of elm. Whitmore Lake, Washt. Co., Nov. 2, leg. C. H. K. This is a very interesting plant because of its spores, which are sordid blue in mass. It is uncommon. Dr. Farlow, to whom it was submitted, kindly sent me a specimen from the Krieger collection of Saxony, Germany. This agreed in all respects with our plants. It was labeled Polyporus caesius Fr. Prof. Peck also referred it to P. caesius, and was corroborated by C. G. Lloyd who happened to be with him. It is also reported by Murrill under the new name Tyromyces caesius (Schrad.) Murrill. I think it worth while to append the description of our specimens.

Pileus thick, dimidiate, sessile, convex, fleshy-coriaceous, becoming hard on drying, pale brownish-buff becoming ashy-tinged, surface *densely tomentose* with rather long hairs, *becoming strigose-rugose*, obscurely or not at all zonate, 5-8 cm. wide, 3-4 cm. long, 1.5-2 cm. thick. Context pure chalk-white, soft when fresh then hard and brittle. Tubes .5-1 cm. long, small, white becoming cinereous; mouths at first white-stuffed then round, dissepiments separating and *becoming lacerate*, finally labyrinthiform, and colored by the spores. Taste and odor not noticeable. Spores 4-5.5 by 1-1.5 micr., slightly curved, deep *bluish-slate color* in mass, subhyaline by transmitted light, shed copiously when plants are fresh.

It is evident as Dr. Farlow pointed out, that this does not conform with the descriptions published by the British mycologists and by Saccardo and Fries (Hymenomycetes Europaei.) These authors refer to the surface as "silky" and give the spore measurements as 13 or 14 micr. long. It would be interesting to see some of their plants.

Polyporus flavovirens B. and Rav. Ground, wooded ravines. Washt. Co., fide C. H. K.

Polyporus Spraguei B and F. (Syn. Tryomyces Spraguei (B and C) Murrill. At base of a living white oak. Washt. Co., Sept. 7, leg. L. H. Pennington, fide Pk.

Agaricaceae.

Amanita flavorubescens Atk. Open Oak woods. Washt. Co., July 31, fide C. H. K.

Clitocybe anisearia Pk. Probably referred to C. odora Fr. at times. Rich woods, on decaying leaves. Washt. Co., Sept. 13, fide C. H. K.

Clitocybe parilis Fr. Ground, open grassy woods. Washt. Co., Oct. 4, fide Pk.
Clitocybe pulcherrima Pk. (type material.) Stevens Station, Wayne Co., Oct. 4, leg. Detroit Mycological Club. Kindness of Dr. O. E. Fischer.
Coprinus semilanatus Pk. On cow dung-hills, pastures. Summer, fide, L. H. P.
Collybia hariolarum Bull. Woods. Washt. Co., Sept. 17, fide Pk.
Collybia hygrophoroides Pk. Low woods. Washt. Co., July 13, fide Pk.
Collybia strictipes Pk. Rich woods. Washt. Co., Sept. 13, fide C. H. K.
Cortinarius albidus Pk. Low woods, Whitmore Lake. Washt. Co., Oct. 4, fide C. H. K.
Cortinarius arenatus (Pers.) Fr. Densely caespitose around base of stump in low woods. Whitmore Lake, Washt. Co., Oct. 4, fide C. H. K.
Cortinarius badius Pk. Ground, low woods. Washt. Co., Oct. 4, fide C. H. K.
Cortinarius camphoratus Fr. Ground, low woods. Washt. and Wayne Co., Aug., fide C. H. K.
Cortinarius rigidus (Scop.) Fr. Oak and Maple woods. Washt. Co. Sept. 17, fide C. H. K.
Crepidotus versutus Pk. On decaying wood, rich woods. Washt. Co., Sept. 13, fide C. H. K.
Entoloma clypeatum Fr. Bare soil, open woods. Washt. Co., July 30, fide Atk.
Entoloma cyaneum Pk. Among grass and leaves, sandy soil. Marquette, Sept. 4, fide Atk.
Entoloma griseum Pk. Woods. Washt. Co., Sept. 12, fide C. H. K.
Entoloma majale Fr. Swampy woods, Washt. Co., Sept. 14, fide C. H. K.
Entoloma sericeum Bull. Among leafmold in woods. Washt. Co., Sept. 17, fide Atk.
Entoloma speculum Fr. Among leafmold, woods. Washt. Co., Sept. 17, fide Atk.
Flammula polychroa Berk (in sense of Atkinson.) Low woods, on dead fallen branches. Washt. Co., Sept. 11, fide C. H. K.
Hebeloma albidulum Pk. Oak and maple woods. Washt. Co., Sept. 30, fide C. H. K.
Hebeloma crustuliniforme Bres. Low woods. Washt. Co., Oct. 4. Gills distilling drops. fide C. H. K.
Hebeloma hiemale Bres. Hillside in grove, Ann Arbor. Early spring and late fall. fide Atk.
Hebeloma strophosum Fr. Sandy ground under thickets. Washt. Co., Oct. 18, fide C. H. K.
Hebeloma Syrjense Karst. Subcaespitose on the ground in woods. Apparently very much like H. testaceum, but with no cortina at any stage. Washt. Co., Oct. 4, fide C. H. K.
Hebeloma sinapizans Fr. In large troops, wooded hillsides. Washt. Co. Sept. 29, fide Atk.
Hebeloma testaceum (Batsch.) Fr. Among decaying leaves, oak and maple woods. Washt. Co. Sept. 28, fide Pk.
Hygrophorus fuligineus Frost. Low woods. Washt. Co., Oct. 5, fide C. H. K.
Hygrophorus Laurae Morg. Erroneously referred to H. glutinosus Pk. in a previous report. Oak and maple woods. Washt. Co., Sept. 17, fide C. H. K.

Hygrophorus pudorinus Fr. Low, grassy woods. Washt. Co., Oct. 19, fide C. H. K.
Hygrophorus subviolaceus Pk. Rare, low woods. Whitmore lake, Washt. Co., Oct. 4, fide C. H. K.
Hypholoma hydrophilum Bull. Around stumps in woods. Washt. Co., June, fide C. H. K.
Hypholoma rugocephalum Atk. Low, swampy woods. Washt. Co., Sept. 6, fide C. H. K.
Hypholoma sublateritium (Schaeff.) Fr. Woods. Washt. Co., Sept. fide C. H. K.
Inocybe subochracea Pk. Low woods. Wayne Co. Aug. 7. fide C. H. K.
Lactarius atroviridis Pk. Low woods. Wayne Co., Aug. 17, fide C. H. K.
Lactarius corrugis Pk. Low woods. Wayne Co., Aug. 17, fide C. H. K.
Lactarius croceus Burling. (in ed.) Low woods. Wayne Co., Aug. 7, fide Miss Burlingham.
Lactarius fuliginosus Fr. Woods. Washt. Co., Aug. 6, fide C. H. K.
Lactarius helvus, var. aquifluus Pk. On sphagnum. Washt. Co., Sept. 14, fide C. H. K.
Lactarius subdulcis, var. oculatus Pk. Sphagnum bog. Washt. Co., Sept. 17, fide C. H. K.
Lepiota miamensis Morg. On ground, rich woods. Washt. Co., Sept. 13, fide C. H. K.
Marasmius Copelandi Pk. On fallen leaves of red oak, woods. Washt. Co., Sept. 17, fide C. H. K.
Marasmius resinosus Pk. Attached to fallen leaves. Washt. Co., Sept. 8, fide Pk.
Marasmius capillaris Morg. On fallen oak leaves. Washt. Co., Sept. 14, fide C. H. K.
Mycena constans Pk. Ground among mosses, Washt. Co., Sept. 14, fide C. H. K.
Mycena leptocephala Pers. On decaying leaves, rich woods. Washt. Co., Sept. 14, fide C. H. K.
Mycena minutula Pk. On bark, in woods. Washt. Co., Sept. 14, fide C. H. K.
Nolanea caelestina Fr. var. violacea Kauff. Gills are narrower than the type, and spores more elliptic.
Pileus lavender, conico-campanulate, 8-10 mm., inniately silky-fibrillose, even on the margin; gills subdistant, white then flesh color; stem lavender, darker than cap, slender, 5 cm. long, 1 mm. thick, even, glabrous, pruinate at apex, equal. Spores tubercular-elliptical, 9-11 by 6-7 micr. Washt. Co., Sept. 11.
Panus torulosus Fr. On rotting stumps, low woods. Washt. Co., Sept. 11, fide C. H. K.
Pholiota Johnsoniana Pk. Rich woods, on leaf-mold. Washt. Co., Sept. 13, fide C. H. K.
Pleurotus elongatipes Pk. (type material.) Stevens Station, Wayne Co., Oct. 4, Detroit Mycological Club. Kindness of Dr. O. E. Fisher.
Psathyra flavogrisea Berk. On moss and liverworts. Bay View, Mich., Sept. 20, 1906, fide C. H. K.
Psathyra obtusata Fr. On very rotten wood, in cedar swamp. Bay View, Sept. 19, 1906, fide C. H. K.
Psathyra umbonata Pk. Among grass. Washt. Co., Oct. 6, fide C. H. K.

Russula albidula Pk. Oak and maple groves. Washt. Co., July 22, fide C. H. K.

Russula fallax (Schaeff.) Sacc. Tamarack and hardwood grove. Washt. Co., Sept. 8, fide C. H. K.

Russula granulata, Pk. Lawns and roadsides. Washt. Co., July 4, fide C. H. K.

Russula obscura Rom. Low woods, Washt. Co., July 30, fide C. H. K.

Russula nigrescentipes Pk. Low woods. Jackson, Mich., Sept. 8, fide C. H. K.

Russula ochrophylla Pk. Oak and maple woods, Washt. Co., June 12, fide C. H. K.

Russula pusilla Pk. Balsam and hemlock swamp. Sault St. Marie, July 11, 1906, fide Pk.

Russula purpurina Quel. and Schulz. Maple, birch, and poplar woods. Houghton, Marquette and Munising. Aug. and Sept. 1906, fide C. H. K.

Russula sordida Pk. Chelsea, Mich. July 20, fide C. H. K.

Russula sororia Fr. Rich woods. Washt. Co., Sept. 13, fide C. H. K.

Russula uncialis Pk. Oak and maple woods. Washt. Co., July 20, fide C. H. K.

Tricholoma fumescens Pk. Ravines of oak and maple woods. Washt. Co., Sept. 14, fide C. H. K.

Tricholoma fumosiluteum Pk. On decaying leaves. Woods, Washt. Co., Oct. 11, fide Pk.

Tricholoma leucocephaloides Pk. Low woods. Washt. Co., Oct. 4, fide C. H. K.

Tricholoma terreolens Pk. Low woods. Washt. Co., Sept. 14, fide C. H. K.

Tricholoma transmutans Pk. Oak woods. Washt. Co., Aug. 17, fide C. H. K.

GASTEROMYCETES.

(Unreported.)

Phallaceae.

Mutinus elegans (Mont.) E. Fischer. On a lawn, Palmyra, Lenawee Co., Dr. B. A. Sprague, Sept. 15.

Dictyophora duplicata (Bosc.) E. Fischer. Probably reported before as Phallus impudicus L. July and Aug., Washt. Co., fide C. H. K.

Hysterangiaceae.

Phallogaster saccatus Morg. On rotten wood. Cascade Glen, Ann Arbor.

Hymenogastraceae.

Hymenogaster nanus Mass. Partly buried in the ground, in a grove. Ann Arbor, July 30, legit Mr. G. H. Coons, fide C. H. K.

Lycoperdaceae.

Bovistella echinella (Pat.) Lloyd. Reported from Mich. by Lloyd.

Calvatia elata Mass. Ground in a swamp. Washt. Co., Oct. legit J. B. Pollock, fide C. H. K.

Lycoperdon atropurpureum Vitt., var. floccosum. Ground in woods. Washt. Co., Sept. 14, fide C. H. K.

Lycoperdon atropurpureum Vitt., var. umbrinum. Reported for Mich. by Lloyd.

Lycoperdon coloratum Pk. Upper Peninsula, 1906. Also reported by Lloyd.

Lycoperdon echinatum Pers. Reported for Mich. by Lloyd.

Lycoperdon muscorum Morg. Reported for Mich. by Lloyd.

Lycoperdon pyriforme Fr. var. serotinum. Reported for Mich. by Lloyd.

Lycoperdon pyriforme Fr. var. faveolum. Reported for Mich. by Lloyd.

Lycoperdon pulcherrimum Pk. Washt. Co., Sept. 14, fide C. H. K. Also by Lloyd.

Lycoperdon rimulatum Pk. Reported for Mich. by Lloyd.

Lycoperdon Wrightii B. and C. Reported for Mich. by Lloyd.

Sphoerobolaceae.

Sphoerobolus stellatus Tod. Among decaying leaves in woods. Washt. Co., Sept. fide C. H. K.

Nidulariaceae.

Crucibulum vulgare Tul. Washt. Co., fide C. H. K.

Cyathus stercoreus (Schr.) De Toni On dung. Washt. Co., fide L. H. P.

OUTLINE OF THE GASTEROMYCETES.

It has been felt for some time that there is no available source of information on the Gasteromycetes of the state. It is true that various monographs exist, but they are scattered in the Botanical Journals out of reach of ordinary students. The most satisfactory for amateurs is the set of notes, beautifully illustrated with good photographs, which are distributed by Mr. C. G. Lloyd of Cincinnati, Ohio. But these are somewhat confusing to the beginner, first because full descriptions are lacking, and the information is somewhat scattered, and second, because Mr. Lloyd uses names which seem at variance with the names which appear elsewhere in books on fungi. The task was therefore undertaken to compile an "outline" from the various papers at my command, with the view of furthering the study of the puff balls of the state, and of elucidating if possible the use of the different names used by different writers. It is to be understood at the outset that the author of this presumes no critical knowledge of buff balls. Moreover, in looking over monographs, etc., during the preparation of this paper, it became evident that even the doctors disagree. It was therefore necessary in many cases to reach an independent decision as to the name to be used for each species included in the outline. Every species which has been reported for the state, and a few others worth looking for, have been included in the outline. The name which seemed in most general use, and adopted by the majority of monographers was in most cases placed first. Following this, there is a list of names, mostly synonyms, which have been used by various people for the same fungus. These lists do not include all the synonyms, especially not the rarer ones, and not such as a student would hardly ever meet in his reading. They are intended to include the names in the monographs and in the mushroom books of this country. Some important ones may have been omitted, and the writer will be pleased to have his attention called to such omissions.

The Gasteromycetes are a large group characterized by the fact that the hymenium of the fruiting bodies is concealed until the spores are mature and ready for dispersion. They contain rare and most interesting fungi as well as the common puff balls. In characterizing the larger divisions, Massee, and Engler and Prantl have been freely consulted, and it is hoped that the necessarily brief descriptions of the orders and families are sufficiently clear for the purpose intended. The keys to species have been adapted from the monographs referred to below. The inclusion of full descriptions was found impracticable in a paper of this kind, but it is hoped that the means may be found to publish for the State a properly illustrated report of this group in the form of a manual.

The following papers on the Gasteromycetes have been consulted and should be used by the student whenever accessible.

Fischer Ed. in Engler und Prantl's *Die Naturlichen Pflanzenfamilien.* Vol. I. 1., pages 276-346. (1900).

Lloyd, C. G. *Mycological Notes.* (1897-1908.)
" " *The Genera of Gasteromycetes.* Cinn. Ohio. (1902.)
" " *The Gastreae.* Cinn. Ohio. (1902.)
" " *The Lycoperdaceae of Australia, etc.* Cinn., Ohio. (1905.)
" " *The Tylostomeae.* Cinn., Ohio. (1906.)
" " *The Nidulariaceae.* Cinn., Ohio. (1906.)
" " *The Phalloids of Australasia.* Cinn., Ohio. (1907.)
Massee, Geo. A Monograph of the Genus Lycoperdon. *Jour. Roy. Microscop. Soc.*, Vol. VII., page 701. (1887.)
Massee, Geo. British Gasteromycetes. *Annals of Bot.*, Vol. IV. (1889.)
Morgan, A. P. North American Fungi: Gasteromycetes. *Jour. Cincinnati Soc. of Nat. History.* Vol. XI., p. 141; Vol. XII., p. 8, and p. 163; Vol. XIII., p. 5; Vol. XIV., p. 141; (1889-92.)
Morgan, A. P. The North American Geasters. *Amer. Naturalist,* Vol. XVIII., p. 963. (1884.) Also, Jour. of Mycol. Vol. 3, p. 11. (1885.)
Peck, Chas. H. United States species of Lycoperdon. *Trans. Albany Institute,* Vol. IXb, p. 285. (1879.)
Trelease, William. The Morals and Puff-Balls of Madison. *Trans. Wis. Acad. of Science.* Vol. VII., p. 105. (1889).
White, V. S., Miss. The Tylostomaceae of North America. *Bull Torr. Bot. Club.* Vol. XXVIII., p. 421. (1901.)
White, V. S., Miss. The Nidulariaceae of North America. *Bull. Torr. Bot. Club.* Vol. XXIX., p. 5. (1902.)
Hollos is hardly accessible enough.

The Gasteromycetes are divided into five orders as follows:

I. *Phallinales.*
II. *Hymenogastrinales.*
III. *Lycoperdinales.*
IV. *Plectobasidinales.*
V. *Nidulariinales.*

Representatives of these orders, all of which occur in Michigan, will be arranged under their respective families.

I.

Phallinales. (The Stink-horns.)

The spores are borne in a special structure, the gleba, which deliquesces to a soft slimy mass, and is elevated at maturity by the elongation of the soft, fleshy and several-layered, much-differentiated fruit-body. Usually foetid. There are two families. Only one is found in our flora.

Phallaceae.
Mutinus.
1. Mutinus elegans. (In sense of Lloyd.)
Other names:
Mutinus Curtisii (Berk.) E. Fischer.
Mutinus bovinus Morg.
Mutinus caninus (Huds.) Fr. Said to occur only in Europe and E. N.

America. Mutinus is recognizable by its horn shape and the apex not enlarged. The color is deep pink to red. I have seen only two collections from Mich.

Mutinus Ravenelii Berk. is more club-shaped. Not reported.

Mutinus caninus (Huds.) Fr. probably does not occur within our limits.

Dictyophora.

This genus includes the common large stink-horns with a differentiated, somewhat ovate apex or cap. In some species there is a large lace-like veil depending from the cap; others have merely a rudiment of a veil. At the base of the stem is a large cup-shaped volva. The odor becomes putrid at maturity of spores. We have apparently only two species.

1. Dictyophora duplicata (Bosc.) E. Fischer. (In sense of Burt and Atk.)

Other names:

Dictyophora phalloidea Desv. (In Engler and Prantl.)

Hymenophyllus indusiatus Ven.

Phallus duplicatus Bosc. (In Morgan and Lloyd.)

This species has large reticulations on the cap and a large pendant veil when fresh. Probably found throughout the state. It grows singly or in small numbers on the ground in woods or clearings. It is 15-20 cm. high and about 5 cm. in diam. at apex. Common at Ann Arbor.

2. Dictyophora Ravenelii (B. and C.) Burt. (In sense of Burt and Atk.)

Other names:

Ithyphallus Ravenelii (B and C.) E. Fischer. (In Engler and Prantl.)

Phallus Ravenelii, B. and C. (In Morgan and Lloyd.)

Phallus impudicus (L.) Fr. (In various reports.)

This species has hardly any veil; sometimes it is taken to be absent and the species is then referred to Phallus impudicus. Pileus is not reticulate. Found on old logs, sawdust, or around rotting wood, usually in the woods. It has not been reported from the northern part of the state.

Phallus impudicus (L.) Fr. is not certainly found in this country according to Lloyd, although Peck, Schweinitz, etc., have so reported it. The veil is entirely absent.

II.

Hymenogastrinales. (The underground puff-balls.)

The fruit-body is mostly subterranean, sometimes above ground. Capillitium is lacking. The spores are borne on a hymenium which lines the interior of variously-shaped chambers, and, with the gleba (which corresponds to the trama of Agaricus), persists till the fruit-body falls apart or deliquesces. There are three families.

Secotiaceae.

1. Secotium acuminatum Mont. (In sense of Engler and Prantl, Lloyd and Setchell.)

Other names:

Secotium Warnei Pk. (In Peck.)

Secotium Agaricoides (Czern.) Holl.

Secotium Thunii. Schulzer.

Lycoperdon Warnei Pk. and Podaxon Warnei Pk.

Above ground. A columella of sterile tissue extends like an axis from

base to apex of fruit-body. Ripe spore-mass powdery. Dirty white peridium.

Hysterangiaceae.

1. Phallogaster saccatus Morg. This seems almost more closely related to the Phallinales, since the gleba deliquesces at maturity. It grows on rotten wood near Ann Arbor, to which it is attached by white strands. Fruit-body small, pear-shaped. Rare. Above ground.

Most of the family are subterranean; the columella if present does not extend through the fruit-body.

Hymenogastraceae.

1. Hymenogaster nanus Mass. was found within the city of Ann Arbor in a grove. It has the appearance of a tuber, but has basidia instead of asci. It grows underground. Careful search might reveal many more in the state.

III.

Lycoperdinales. (The puff-balls.)

The fruit-body is above ground. A capillitium is present and its threads are mixed with the copious spores which fill the fruit-body with a dry, dusty mass when mature. The peridium is composed of two layers; the outer layer may be a firm and persistant coat bursting or splitting into fragments, or it may be soft, fragile and more or less deciduous (called cortex.) The various modes of dehiscence of the outer or inner layer determines largely the genus. There is only one family.

*Lycoperdaceae.**

Key to Genera.

(a) Outer peridium thick, splitting into star-like segments which become reflexed..(b)

(a) Outer peridium (cortex) soft, *disappearing* or temporarily persisting as warts or spines, flocci, etc....................................(c)

(b) Columella present; threads of capillitium simple, tapering to each extremity..1. *Geaster.*

(b) Columella none; capillitium threads very long and interwoven
Astraeus. (See Plectobasidinales.)

(c) Fruit-body globose, entirely filled by spores and capillitium, i. e., without a sterile base, loosened at maturity from place of growth......(d)
(Bovistella echinella has no sterile base.)

(c) Fruit-body sub-globose, obovoid or turbinate, tending to be longer than broad, with sterile tissue within the stem-like base, normally remaining attached to place of growth......................................(f)

(d) Outer peridium splitting in two, so that lower part remains in the ground; inner peridium dehiscing by a pore on the under side and carrying upper half of outer peridium with it when loosened from the place of growth. Capillitium threads simple.............................2. *Catastoma.*

(d) No such splitting of outer peridium............................(e)

(e) Threads of capillitium free, short, dichotomously branched.
3. *Bovista.*

*Considerable disagreement is shown by different mycologists in the placing of the various species, largely due to the absence of exact knowledge of the development of different forms, so that a species has been put under a number of different genera from time to time.

(e) Threads of capillitium with scattered prickles; peridium very thick and leathery..4. *Mycenastrum.*

(f) Peridium flaccid, opening by a definite mouth..................(g)

(f) Peridium brittle, breaking into fragments from above downwards; with long branched capillitium threads..................5. *Calvatia.*

(g) Spores with distinct, permanent pedicels..........6. *Bovistella.*

(g) Spores not pedicillate; threads of the capillitium long and slender, simple or branched....................................7. *Lycoperdon.*

1. *Geaster.*

Key to species:*

(a) Exoperidium recurved....................................(b)

(a) Exoperidium fornicate......................Geaster coronatus.

(a) Exoperidium saccate........................Geaster saccatus.

(b) Plant large, reddish-brown..................................(c)

(b) Plant small................................Geaster minimus.

(c) Unexpanded plant globose; columella large, thick, globose. Geaster rufescens.

(c) Unexpanded plant acute; columella elongated, prominent. Geaster triplex.

(a) Geaster coronatus (Schaeff) Schroet.

Other names:

Geaster fornicatus (Huds.) Fr.

This species is not yet reported for our flora. The reflexed exoperidium is arched over the mycelial layer which separates and remains as a cup in the ground, the recurved segments being supported on the raised margin of the cup.

(b) Geaster saccatus Fr.

Other names:

Geaster fimbriatus Fr.

Common in the woods about Ann Arbor, among decaying leaves. The outer peridium recurves but not so as to raise up the sessile globose inner part.

(c) Geaster minimus Schw.

Other names:

Geaster marginatus Vitt.

Reported by Longyear, 4th Report.

(d) Geaster rufescens Fr.

Not yet reported, nor distinguished in the state, but said to be more common than the next. Probably reported under G. triplex.

(e) Geaster triplex Jung.

Abundant throughout the state, either as this species or the preceding. Further observation is necessary to determine the distribution of these two hitherto confused species. See the key.

2. *Catastoma.*

(a) Catastoma circumscissum (B and C.) Morg.

Other name: Bovista circumscissum B. and C.

"Spores globose, minutely warted, 4-5 mic, often with minute pedicel; the capillitium of short pieces of threads, flexuous, hyaline, 3-4 diam."

Reported by Longyear; in sandy fields. Morgan found it in barnyard and cattle lanes on heavy clay soil.

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*Adapted from Lloyd.

(b) Catastoma subterraneum (Pk.) Morg.

Other name: Bovista subterranea Pk.

"Spores globose, distinctly warted, 6-8 mic., sessile"; otherwise similar to the preceding. Reported in 4th. Report by Longyear. In sandy fields.

3. *Bovista.*

(a) Bovista pila B and C.

Other names:

Bovista stuppea Berk.

Bovista tabacina Sacc.

Mycenastrum Oregonense E. and E.

"Spores globose, 3.5-5 mic., sessile or with minute pedicel." Fruit-body over one inch in diameter. Cortex soon disappearing. Peridium dehiscing irregularly. Throughout the state, mostly in woodlots. Common around Ann Arbor.

(b) Bovista plumbea Pers.

Other names:

Bovista nigrescens Pers.

"Spores oval, even, 6-7 by 5-6 mic, with long hyaline pedicels." Fruit-body less than one in. in diameter, dehiscent at apex; cortex shelling off in pieces; inner peridium lead colored. Our commonest Bovista. Throughout the statė, in fields.

4. *Mycenastrum.*

Mycenastrum spinulosum Pk.

A large puff-ball without a stem, up to 4 in. in diameter. Inner peridium almost woody and very thick. Spores in mass-purple brown, 9-12 mic. globose, very minutely warted, often with minute pedicel. Reported by Longyear; on Campus, East Lansing. Other stations should be found.

5. *Calvatia.*

Key to species.

(a) Fruit-body very large, 6 to 12 inches in diameter, without a distinct stem-like base; almost filled by the spores....Calvatia gigantea.

(a) Fruit-body 3-5 in. or less in diameter, with a stem-like base....(b)

(b) Mass of spores violet or purple............Calvatia cyathiforme.

(b) Spore mass greenish-yellow or olivaceous (brown in age) Calvatia coelata.

(b) Spore mass brown or brownish-olivaceous. Fruit-body abruptly contracted into a stem-like base.......................Calvatia elata.

(a) Calvatia gigantea (Schaeff) Batsch. (In sense of Lloyd.)

Other names:

Calvatia maxima Schaeff. (In Morgan.)

Bovista maxima.

Bovista gigantea Nees.

Lycoperdon bovista L. (In Trelease and Massee.)

Lycoperdon maximum Schaeff.

Lycoperdon giganteum Batsch. (In Peck.)

Globaria bovista (L) Quel. (In Engler and Prantl.)

Globularia gigantea Guel.

This is the common giant puffball growing in rich woods or grassy fields. It has been found at a number of stations around Ann Arbor. Distributed throughout the state. It is in great demand for the table, and is best pre-

pared by slicing and frying in egg and bread crumbs. Peck quotes from the Country Gentleman an account of a specimen eight feet in circumference and weighing forty-seven pounds. This is the extreme size, though they occasionally grow to a diameter of 1.5 to 2 feet in our area.

(b) Calvatia cyathiforme (Bosc.) (In sense of Morgan.)

Other names:

Calvatia lilacina (B. and M.) Lloyd. (Lloyd insists that this name should be used instead of the above.)

Lycoperdon cyathiforme Bosc. (In Peck.)

Lycoperdon fragile Vitt. (The European name, according to Lloyd.)

Bovista lilacina B. and M.

Lycoperdon lilacinum (B. and M.) Speg. (In Engler and Prantl.)

The upper part falls away leaving a wide cup filled with purplish spores and capillitium; sometimes a strong lilac tinge is apparent. Spores globose, distinctly warted or echinulate, 5-7 m diameter. Throughout the state. Mostly in fields. Common around Ann Arbor.

(c) Calvatia caelata (Bull.) (In sense of Lloyd and Morgan.)

Other names:

Lycoperdon caelatum Bull. (In Engl. and Prantl, Massee, Peck.)

Lycoperdon favosum Rostk. (In Trelease.)

Fields and roadsides. Also found on a well-kept lawn at Houghton. Thruout the state. Often somewhat areolate, like the preceding, due to the partial separation of the cortex. Spores globose, 4-4.5 mic.

(d) Calvatia elata Mass. (In sense of Morgan.)

Other name:

Calvatia saccata Vahl. Said to be the European form of our plant. Our plants have some of the characters of both C. saccata and C. elata. The stem of this Calvatia is more differentiated, and deeply wrinkled, than the preceding. Low grounds, 1st Sister Lake, Ann Arbor.

6. *Bovistella.* (In sense of Lloyd.)

(a) Bovistella pedicellata (Pk.) Lloyd.

Other names:

Lycoperdon pedicellatum Pk. (In all authors.)

Cortex of long spines, falling away and leaving a smooth inner peridium. Gleba olive or brown. Spores globose, smooth, 4-5 mic., with very long pedicels, 20-24 mic. long. The only other plants in our flora with such shaggy spines on the peridium are Lycoperdon pulcherrimum B. & C. and Lycoperdon echinatum Pers. In woods; throughout the state. Not very common.

(b) Bovistella ohinesis Ell. & Morg. has not been reported from our flora.

Other names: Scleroderma Ohiense DeToni. (In Saccardo.) Mycenastrum Ohiense Ell. & Morg. (In Jour. of Mycol. Vol. 1.)

"Cortex a dense floccose coat, leaving a smooth pale brown or yellowish surface to the inner peridium." Gleba olive or brown. Spores 4-5, mic. globose, with pedicels 10-12 mic. long. Fruit-body plicate underneath with a thick, cord-like root.

(c) Bovistella echinella (Pat.) Lloyd.

A rare puff-ball, sent to Lloyd from Michigan by Longyear; very small, half a centimeter in diameter, dark reddish brown. Cortex of minute tufted spines, in patches. Sterile base none. Gleba olive-brown. Spores globose, 4-5 mic. smooth, with pedicels about 10 mic. long. Usually grows on Funaria hygrometrica.

7. *Lycoperdon.*

Key to species.*

(a) Mature spores purplish-brown, large, rough, 5-7 mic. diam.....(b)

(a) Mature spores yellowish, brown, or olive, smooth or only minutely rough. 3.5-5 mic. diameter..............................(f)

(b) Cortex spinulose or shaggy..............................(c)

(b) Cortex not at all shaggy..............................(e)

(c) Gleba turning purple quickly when full-grown; cortex of long, convergent spines..............................(d)

(c) Gleba olive or umber, slowly turning purple. Spines slender, cruciate, soon disappearing..................1. Lycoperdon atropurpureum.

(d) Spines *black;* the denuded peridium reticulate with circles of minute spinules..............................2. Lycoperdon echinatum.

(d) Spines white, (brownish when old); denuded peridium smooth
3. Lycoperdon pulcherrimum.

(e) Cortex a soft floccose covering, cream-color or yellow when fresh. Threads as thick as the spores..........4. Lycoperdon glabellum.

(e) Cortex smooth and continuous, gray or bluish-gray. Threads always thinner than spores..................5. Lycoperdon rimulatum.

(f) Fruit-body decidedly yellowish, small. Sterile base of compact, minute cells..........................6. Lycoperdon coloratum.

(f) Fruit-body not yellowish, or only slightly tinged..............(g)

(g) Growing on mosses, especially Polytrichum. Cortex of spinules and granules..........................7. Lycoperdon muscorum.

(g) Growing in clusters on stumps, logs or very rotten wood, with long white, mycelial strands ....8. Lycoperdon pyriforme and varieties.

(g) Growing on the ground in woods (rarely on very rotten wood.)
9. Lycoperdon gemmatum and varieties.

(g) Growing in pastures, fields, roadsides or other grassy places........(h)

(h) Cortex of small spines, flaking off, but not in large pieces as in the next. Capillitium of thick, hyaline threads, 2-3 times thicker than spores..............................10. Lycoperdon Wrightii.

(h) Cortex of strong, cruciate spines, peeling off in patches. Capillitium brownish, some hyaline, not much thicker than the spores
11. Lycoperdon cruciatum Rost.

1. Lycoperdon atropurpureum Vitt. (In sense of Lloyd.)
(For varieties, see below.)
Other names:
Lycoperdon atropurpureum var. hirtellum. (In Peck.)
Lycoperdon echinatum Pers. (Young stage, in Peck.)
Lycoperdon Peckii Morg. (per Lloyd.)
Lycoperdon perlatum Pers. (In Morgan.)
Lycoperdon hirtum Pers. (per Lloyd.)
Lycoperdon hirtum Mart. (per Morgan.)

Very variable mostly as to the nature of the cortex. Hence described as a number of varieties. The spines are slender, 2 mm. long. Spores rough, mixed with fallen pedicels, 5-7 mic. Fruit-body medium size, obovate, etc.

1a. Var. Lycoperdon floccosum. (In sense of Lloyd.)
Other name:
Lycoperdon elongatum Berk. (In Morgan and Lloyd.)

* Adapted from Trelease and Lloyd.

Cortex with only a few large soft flocculent spines. Reported by Longyear. Common at Ann Arbor.

1b. Var. Lycoperdon umbrinum Fl. Dan. (See Lycoperdon glabellum Pk.)

Other names:

Lycoperdon constellatum Fr. (In Massee.)
Lycoperdon elegans Morg. }
Lycoperdon delicatum Berk. } (per Lloyd.)
Lycoperdon glabellum Pk. }

2. Lycoperdon echinatum Pers. (In sense of Morg., Massee and Lloyd.)

Other names:

Lycoperdon constellatum Fr. (In Pk. and Trelease.)

Spines black to dark-brown. Spores are distinctly rough, globose, 6-7 m. Rare. Reported from Mich. by Lloyd.

3. Lycoperdon pulcherrimum B. & C. (In sense of Trelease, Morgan, Lloyd and Mass.)

Other name:

Lycoperdon Frostii Pk.

A very beautiful puff-ball, usually found solitary, but quite common thouout the state. In age the spines may become brownish. Spores 6-7 mic, glubose, minutely warted.

4. Lycoperdon glabellum Pk. (In sense of Massee, Morgan, Trelease and Peck.)

Lycoperdon atropurpureum, var. umbrinum. (In Lloyd.)

Spores distinctly warted, globose, 5-6 mic. Whatever its relationship it seems to be fairly easily recognizable in the field, hence is kept distinct. Lloyd does not recognize it as such. Has obovoid shape, as a rule. Probably thruout the state.

5. Lycoperdon rimulatum Pk. (In sense of Lloyd, Morg. and Trelease.)

"Spores rough-warty, 5-7 mic. with pedicels 2 mic. long." (Trelease.) The outer peridium cracks somewhat as in Calvatia coelatum. Fruit-body with strong tap-root. Reported from Mich. by Lloyd.

6. Lycoperdon coloratum Pk. (In sense of Trelease and Morgan.)

Other name:

Lycoperdon cepaeforme Bull. (In Massee and Lloyd.)
Lycoperdon polymorphum. (per Lloyd.)

"Cortex minutely granular, furfuraceous, or of minute fasciculate spines, at first smooth." Spores citron or sulfur-yellow, *smooth*, globose. Reported from Mich. by Lloyd; found in the Upper Peninsula by the writer. Usually solitary.

7. Lycoperdon muscorum Morg. (In sense of Morg. and Lloyd.)

Other names:

Lycoperdon colle Pers. (In Peck.)

Spores minutely warted, 4-4.5 mic. in diam. Fruit-body with white or yellowish cortex. Small, .5-1.8 inches in diam. Reported in Mich. by Lloyd.

8. Lycoperdon pyriforme Schaeff. (In sense of Lloyd.)

Of world-wide distribution, and very common. It is quite variable, and hence certain varieties have been given names. The typical form has smooth spores. 4 mic. in diameter, and the cortex is composed of minute branny scales or granules. Everywhere in the state.

8a. var. Lycoperdon tessellatum. (Sense of Lloyd.)

"The cortex is broken up in indurated areas." Reported by Longyear. We have two collections from Ann Arbor, found in autumn.

8b. var. Lycoperdon serotinum. (Sense of Lloyd.)

Here the cortex is thinly areolate, like the marks of an insect on a leaf. Specimens exactly like the one in Lloyd's figure, were collected at Whitmore Lake, Washt. Co., by the writer.

8c. Var. Lycoperdon faveolum. (Sense of Lloyd.)

This has the fruit-body pitted or alveolar; probably abnormal. Sent to Lloyd from Mich. by Longyear. Not elsewhere reported.

9. Lycoperdon gemmatum Batsch.

Other names:

Lycoperdon perlatum Pers. (Not of Morg.)

"No plant is more variable in size, shape, color and spines." Several varieties have been named. This and Lycoperdon pyriforme are the two most common puff-balls in the state. It is known by the large, erect, pointed, warts around the upper part; these fall off, leaving impressions, around which smaller warts are situated forming fine reticulated dotted lines. Spores very minutely rough, *small*, 4 mic. diam.

9a. Var. Lycoperdon hirtum Mart. (Sense of Peck.)

Other name:

Lycoperdon perlatum Pers. (per Morgan.)

Cortex of slender, bristle-like spinules, instead of the large warts.

9b. Var. Lycoperdon papillatum Schaeff. (Sense of Peck.)

Crowded warts of uniform size, appearing papillose, take the place of the large warts. Fruit-body subrotund, without the usual stem-like base.

10. Lycoperdon Wrightii B. & C. (In sense of Lloyd.)

Other names:

Lycoperdon Curtisii. (In Morgan.)

Lycoperdon Wrightii var. typicum. (In Peck.)

Spores small, 3-4 mic., smooth. Reported from Mich. by Lloyd. In yards, gardens, paths, etc., among the grass.

11. Lycoperdon cruciatum Rost. (In sense of Lloyd.)

Other names:

Lycoperdon separans Pk. (In Morgan.)

Lycoperdon Wrightii, var separans Pk. (In Peck.)

Lycoperdon papillatum Schaeff.

In pastures and fields. Very common. Spores globose, smooth, 4 mic. diameter. Can be recognized by the cortex coming off in pieces.

12. The following species should be looked for:

Lycoperdon Turneri E. & E.

Lycoperdon subincarnatum Pk.

Lycoperdon acuminatum. Bosc.

Lycoperdon Polytrichum.

IV.

PLECTOBASIDINALES.

The fruit-body is either above ground or subterreanan, sometimes stalked. The basidia are distributed uniformly thruout the gleba; no special air-chambers are present. There are five families, of which the following are represented in Michigan.

(1) *Sclerodermataceae.*

Fruit-body irregularly globose, with no stalk. Capillitium rudimentary. Scleroderma, the only genus represented, is normally above ground. Melanogaster is a subterranean tuber-like plant, and should be found in the state.

Scleroderma.

Scleroderma differs from ordinary puff-balls in its tough, hard, and leathery peridium, and the dark-colored sporemass, each spore being covered till almost ripe by a layer of hyphae. Not edible.

Key to species. (Adapted from Lloyd.)

(a) Peridium opening by stellate lobes .... (b)
(a) Peridium opening by an irregular mouth .... (c)
(b) Peridium thick, rough and black ...... 1. Scleroderma Geaster Fr.
(b) Peridium thick, smooth, yellowish ...... 2. Scleroderma flavidum. Ell.
(c) Peridium yellowish-buff, thin, dotted with dark, angular, small scales. Never verrucose .... 3. Scleroderma verrocosum Vaill.
(c) Peridium furrowed or sculptured .... 4. Scleroderma vulgare. Fr.

1. Scleroderma Geaster Fr. has not yet been found in the state.
Other names;
Sclerangium polyrhizon (Gmel.) Lev. (In Engler and Prantl.)

Stella americana Massee. (per Lloyd.)

2. Scleroderma flavidum. Ell.

Reported from Mich. by Longyear in 4th Report. Unopened plants look like forms of Scleroderma vulgare.

3. Scleroderma verrucosum (Bull.) Pers.
Other names:
Scleroderma Bovista (In Ellis' N. A. F.) (per Trelease.)

Common about Ann Arbor. Thruout the state. Sometimes it is somewhat stalked.

4. Scleroderma vulgare Fr.
Other names:
Scleroderma aurantiacum (Vaill.) Pers. } (per Lloyd.)
Scleroderma cepa }

Quite variable, form depending on the weather. Thruout the state.

2. *Calostomataceae.*

Two genera are included here. Only one, Astraeus, has been reported. This has the appearance of a true Geaster, and used to be placed there. The other genus is Calostoma; this has the peridium raised on a root-like, cartilaginous stalk. The highly differentiated, several-layered peridium (head), distinguishes this family.

Astraeus stellatus (Scop.) E. Fischer.
Other names:
Geaster hygrometricus Pers.
Astraeus hygrometricus Morg.

The 5-15 or more segments are very rigid, and very hygroscopic. Plants medium size. It develops underground, generally on sandy soil. Thruout the state.

3. *Tylostomaceae.*

Fruit-body distinctly stalked, developing from below ground. The stems are more or less uniform in thickness, with a puff-ball like head. It dehisces

by a definite mouth. Capillitium is present. Gleba not chambered. Spores usually 5-6 mic., dry. Only one genus is reported. The various species from Mich. can be referred to three species.

Key to species. (Sense of Lloyd and White.)

(a) Mouth *entire*, rather cylindrical, short, round, protruding. Tylostoma rufum.

(a) Mouth surrounded by a fimbriate cushion .... (b)

(b) "Mouth with a small development of fibrils, usually torn and granular in appearance." Stipe short, thick.................Tylostoma campestre.

(b) Mouth raised, somewhat tubular, but lacerate. Stipe slender. Tylostoma fibrillosum.

(a) Tylostoma rufum Lloyd.

Other names:

Tylostoma mammosum Fr. (4th Mich. Report.)

Tylostoma pedunculatum (L) Schr. (In Miss White's paper.)

Reported for Mich. by Longyear, also by Miss White as from McBride. According to Lloyd, the true T. mammosum does not occur in America. The inner peridium is reddish-brown, with a strongly protruding mouth. Stem is deep-colored, short scaly, white within. Spores 5 mic, granular.

(b) Tylostoma campestre Morg.

Other names:

Tylostoma granulosum Sw.? (N. A. Fungi by Ellis and Everhart, No. 3297 (European form according to Lloyd.)

Tylostoma fimbriatum Fr. (per Lloyd.)

Two collections from Michigan are reported by Lloyd as sent by Longyear. This is the most common species in the United States. The peridium is whitish; the cortex is a sand case, brown-scaly underneath the sand, and gradually falling away. Mouth torn and granular in appearance, not prominent. Stipe dark, striate-sulcate, rather short and thick. Capillitium hyaline, with few septa, not swollen. Spores granular. In sandy fields, probably thruout the state.

(c) Tylostoma fibrillosum White.

Referred by Lloyd to the preceding. Found by Hicks in Michigan, according to Miss White. It was found by me west of Chelsea in a sandy grass field. Miss White illustrate our plants well, except that the mycelium of the stem is washed off many of them. The inner peridium is dull chalk-white, the mouth is round, somewhat protruding and usually surrounded by a definite lacerate, cushion of fibrils. The capillitium is hyaline, swollen at the joints, and the spores are minutely but distinctly asperate, ochraceous-brown in mass with a pink tinge.

4. *Sphoerobolaceae.*

Sphoerobolus carpobolus L.

Other name: Sphoerobolus stellatus Tode.

Very minute plants. The fruit-body is whitish, often only 1 to 2 mm. in diameter, globose at first, then the orange-colored slimy interior is expelled at maturity as a sphere. On or under decaying leaves and rotting woods. Probably thruout the state.

NIDULARIINALES. (Birds' nest fungi.)

Fruit-body not large, above ground, cup or funnel shaped, the cup containing small round bodies (peridioles) which contain the spores. Often on dung, decaying straw, wood, etc. Only one family is included.

Nidulariaceae.

Key to genera.

(a) The opening to the cup is covered at first by a thin membrane. Peridioles are attached to a long cord (funiculus.)......................(b)
(a) Opening without a membrane..................1. *Nidularia.*
(b) Opening of cup without a margin................2. *Crucibulum.*
(b) Opening of cup with margin......................3. *Cyathus.*

Crucibulum vulgare Tul., Cyathus stercoreus (Schr.) DeToni, and Cyathus vernicosus D. C. are the only three species reported. The order needs attention.

University of Michigan, April 1, 1908.

INDEX.

ADDITIONS TO THE MICHIGAN FLORA AS PUBLISHED IN THE FIFTH REPORT OF THE MICHIGAN ACADEMY OF SCIENCE, 1904.

W. J. BEAL.

The list includes 122 species and varieties of which H. S. Pepoon furnishes 66, collected in Counties Van Buren, Cass and Berrien.

These added to the former list make 2365.

The following seem to be the most interesting.

Andropogon Virginicum L.
Aristida tuberculosa Mutt.
Boltonia asteroides (L) L'Her.
Cassia Chamaecrista L.
Elatine Americana Arn. Growing about an inch high in mud, probably usually overlooked.
Quercus Michauxii Nutt.
Triosteum aurantiacum Bicknell.
Prunus Virginiana L. var. with cream-colored fruit of mild flavor. Collected at Menominee by A. L. Sawyer.

This variety was collected some years ago in Massachusetts by Mrs. H. L. T. Woolcott, Dedham, Mass.

Agrostis intermedia Scribn.
Upland Bent-grass. Cass Co., H. S. Pepoon.

Andropogon Virginicus L.
Virginia Beard-grass. Keeler, Van Buren Co., H. S. Pepoon.

Antennaria ambigens (Greene) Fernald.
Van Buren Co., H. S. Pepoon.

Antirrhinum majus L. Detroit, O. A. Farwell.

Arctium minus Schk.
Common Burdock, Keeler, Van Buren Co., H. S. Pepoon.

Aristida tuberculosa Nutt.
Sea Beach Aristida, Keeler, Van Buren Co., H. S. Pepoon.

Artemisia Pontica L.
Roman Wormwood, Bay City, Geo. M. Bradford.

Ascyrum hyperocoides L.
Near Detroit, O. A. Farwell.

Boltonia asteroides L. L'Her.
Aster-like Boltonia, Van Buren Co., H. S. Pepoon.

Briza media L.
Detroit River Front, O. A. Farwell.

Calamagrostis inexpansa A. Gray.
Bog Reed-grass, Keeler, Van Buren Co., H. S. Pepoon.

Campanula uliginosa Ryd.
Van Buren Co., H. S. Pepoon.

Cardamine Pennsylvanica Muhl.
Pennsylvania Bitter Cress. Keeler, Van Buren Co., H. S. Pepoon.

Carex Baileyi Brit.
Van Buren Co., H. S. Pepoon.

Carex conjuncta Boot.
Keeler, Van Buren Co., H. S. Pepoon.
Carex glaucodea Tuck.
Keeler, Van Buren Co., H. S. Pepoon.
Carex Jamesii Schwein.
Keeler, Van Buren Co., H. S. Pepoon.
Carex paupercula irrigua (Wahl.) Fernald.
Keweenaw Co., O. A. Farwell.
Carex paupercula pallens Fernald.
Keweenaw Co., O. A. Farwell.
Carex marcida Boot.
Thunder Bay Island, Port Huron, C. K. Dodge.
Carex teretiuscula prairea (Dewey). Britton.
Keeler, Van Buren Co., H. S. Pepoon.
Cassia Chamaecristata L.
Partridge Pea. Pipestone, Berrien Co., H. S. Pepoon.
Caucalis nodosa (L) Huds.
In Ballast, Detroit, O. A. Farwell.
Chelone obliqua L. Red Turtle head.
Near Huron River, Ann Arbor, S. Alexander.
Commelina communis L.
Asiatic Day-Flower, Dowagiac, Cass Co., H. S. Pepoon.
Corallorhiza multiflora flavida Peck. Large Coral-root.
Birmingham, S. Alexander.
Crataegus Margaretta Ash.
Dowagiac, H. S. Pepoon.
Cuscuta compacta Juss.
Compact Dodder. Keeler, Van Buren Co., H. S. Pepoon.
Cuscuta paradoxa Raf.
Glomerate Dodder. Berrien Co., H. S. Pepoon.
Dasystoma laevigata Raf.
Birmingham, O. A. Farwell.
Delphinium Ajacis L.
Keeler, Van Buren Co., H. S. Pepoon.
Dipsacus laciniatus L. Lansing, a mile and a half below the College, W. J. B. Cup-leaved Teasle.
Elatine Americana Arnott.
Mud Purslane, Border Round Lake, Van Buren Co., H. S. Pepoon.
Elatine brachisperma A. Gray.
Border of Lake Anne, Houghton Co., C. E. Davis.
Eleocharis melanocarpa Torr.
Priest's Lake, Cass Co., H. S. Pepoon.
Eleocharis palustris calva A. Gray.
Belle Isle, O. A. Farwell.
Equisetum palustre L.
Marsh Horsetail. Silver Creek, Van Buren Co., H. S. Pepoon.
Euphorbia serpyllifolia Pers.
Thyme-leaved Spurge. Agricultural College, escaped from cultivation W. J. B.
Euthamia Caroliniana (L) Greene. *Solidago tenuifolia* Pursh.
Slender Fragrant Golden-rod.
Dewey Lake, Cass Co., H. S. Pepoon.

Eupatorium trifoliatum L.
Crenate-leaved Joe-pye weed. Van Buren Co., H. S. Pepoon.
Galinsoga parviflora hispida D. C.
Detroit, O. A. Farwell.
Galium circaezans glabellum Britton.
Van Buren Co., H. S. Pepoon.
Galium Claytoni Michx.
Clayton's Bedstraw, Dewey Lake, Cass Co., H. S. Pepoon.
Galium tricorne Stokes.
In ballast, Detroit, O. A. Farwell.
Genista tinctoria L.
Detroit, O. A. Farwell.
Geranium Carolinianum L.
Carolina Crane's Bill. Cass Co., and Van Buren Co., H. S. Pepoon.
Helianthus annuus L.
Detroit, O. A. Farwell.
Helianthus atrorubens L.
Hairy-Wood Sunflower, Keeler, Van Buren Co., H. S. Pepoon.
Helianthus laetiflorus Pers.
Showy Sunflower, Keeler, Van Buren Co., H. S. Pepoon.
Helianthus lenticularis Dougl.
Ann Arbor, S. Alexander; Ypsilanti, O. A. Farwell.
Helianthus strumosus mollis T. & G.
Ypsilanti, O. A. Farwell; Ann Arbor, S. Alexander.
Heliopsis helianthoides (L.) B. S. P. H. *laevis* Pers, Addison, W. J. B.; Port Huron, C. K. Dodge.
Hemerocallis flava L.
Yellow Day-Lily. Dowagiac, Cass Co., H. S. Pepoon.
Hemicarpha micrantha (Vahl.) Brit.
Cable Lake, Van Buren Co., H. S. Pepoon.
Hicoria microcarpa (Nutt.) Brit.
Small-fruited Hickory. Keeler, Van Buren Co., H. S. Pepoon.
Hieracium marianum Willd.
Maryland Hawkweed. Keeler, Van Buren Co., H. S. Pepoon.
Hypoxis hirsuta (L.) Coville.
Star grass. Keeler, Van Buren Co., H. S. Pepoon.
Ilex Bronxensis Britton.
Cass Co., H. S. Pepoon.
Juncus marginatus aristatus (Michx.) Coville, Detroit, O. A. Farwell.
Kneiffia linearis (Michx.) Beach.
St. Clair Co., C. K. Dodge.
Lactuca Morssii Robinson. Morss Wild Lettuce.
Turin, U. P., Brunson Barlow.
Lechea racemulosa Michx.
Oblong-fruited Pin-weed, H. S. Pepoon.
Lycopus Virginicus L. Purple Bugle Weed. Near Magician Lake, Van Buren Co., H. S. Pepoon.
Mitchella repens alba.
Partridge-berry. Fruit white. Mrs. Helen W. Paul. Ontonagon.
Naias gracillima (A. Br.) Morong.
Thread-like Naias, H. S. Pepoon.
Onagra biensis cruciata (L.)
Belle Isle, Detroit. O. A. Farwell.

Onagra biennis grandiflora (Ait.) Lind. Detroit. O. A. Farwell.
Onagra biennis muricata L.
Keweenaw Co., O. A. Farwell.
Onagra biennis parviflora.
Detroit, O. A. Farwell.
Panicularia Torreyana.
Van Buren Co., H. S. Pepoon.
Panicum Ashei G. Pearson.
Ashe's Panicum (No specimen), H. S. Pepoon.
Panicum barbulatum Michx.
Keeler, Van Buren Co., H. S. Pepoon.
Panicum lanuginosum Ell. Van Buren Co., H. S. Pepoon.
Panicum laxiflorum Lam.
Lax-flowered Panicum (No specimen), H. S. Pepoon.
Panicum microcarpon Muhl.
Keeler, Van Buren Co., H. S. Pepoon.
Panicum pubescens Lam.
Pine Lake, Van Buren Co., H. S. Pepoon.
Parietaria Pennsylvanica Muhl.
Pennsylvania Pellitory. Keeler, Van Buren Co., H. S. Pepoon.
Polygala cruciata L.
Cross-leaved Milkwort. Sandy Shore, Dewey Lake, Cass Co., H. S. Pepoon.
Polygonum punctatum lepostachyum (Meisn.) Small.
Belle Isle, O. A. Farwell.
Potamogoton lonchitis L.
Detroit, O. A. Farwell.
Potamogeton nitens L.
Detroit, O. A. Farwell.
Prunus avium L.
Mazard Cherry, near Magician Lake, Cass Co., H. S. Pepoon.
Prunus cerasifera Ehrh.
Belle Isle, Detroit, O. A. Farwell.
Prunus Virginiana L.
Choke Cherry, Variety with cream colored fruit of mild flavor. A. L. Sawyer, Attorney, Menominee.
Quercus Michauxii Nutt.
Cow Oak, Basket Oak, Moist wood. N. Keeler, Van Buren Co., very rare, H. S. Pepoon.
Ranunculus Macounii Brit.
Macoun's Buttercup. Hartfort, Van Buren Co., H. S. Pepoon.
Rhynchospora corniculata (Lam.) A. Gray.
Horned Rush. Fox Lake, Van Buren Co., H. S. Pepoon.
Rhexia Virginica L.
Detroit, O. A. Farwell.
Rhus glabra borealis Britt.
Belle Isle, Detroit, O. A. Farwell.
Robinia hispida L.
Rose Acacia, Keeler, Van Buren Co., H. S. Pepoon.
Robinia viscosa Vent.
Clammy Locust. Near Silver Creek, Cass Co., H. S. Pepoon.
Rosa lucida Ehrh.
Glossy Rose. Van Buren Co., H. S. Pepoon.

Rotala ramosior (L) Koehne.
Van Buren Co., H. S. Pepoon.
Rubus Alleghaniensis Porter.
Keweenaw Co., O. A. Farwell.
Rudbeckia Sullivantii Boynton & Beadle.
North Lansing on River bank. Inserted in last catalogue as R. speciosa. W. J. B.
Salix eriocephala Michx.
Pussy Willow. Van Buren Co., H. S. Pepoon.
Salix fluviatilis Nutt.
Sand bar Willow. H. S. Pepoon.
Salix servissima (Bailey) Fernald.
Lakeville. Brotherton & Farwell.
Scandix Pecten-Veneris L.
In Ballast. Detroit, O. A. Farwell.
Scleria pauciflora Muhl.
Nut-rush. Keeler, Van Buren Co., H. S. Pepoon.
Sida spinosa Lin.
Detroit, O. A. Farwell.
Sisymbrium canescens Nutt.
Thunder Bay Island, C. F. Wheeler.
Smilax pulverulenta Michx.
Dowagiac, H. S. Pepoon.
Solidago juncea ramosa Porter.
Detroit, O. A. Farwell.
Solidago rigidiuscula (T. & G.) Porter.
Keeler, Van Buren Co., H. S. Pepoon.
Specularia perfoliata (L.) A. DC.
Venus' Looking Glass. Keeler, Van Buren Co., H. S. Pepoon.
Stenophragma Thaliana (L.) Celak. *Arabis Thaliana L.*
Mouse-ear Cress. H. S. Pepoon.
Symphoricarpos recemosus L.
Snow-berry. Silver Creek, Cass Co., H. S. Pepoon.
Taraxacum erythrospermum Andrez.
Previously only found in Wayne Co., Berrien Co., H. S. Pepoon.
Teucrium menthifolium Bicknell.
Detroit, O. A. Farwell.
Triosteum auriantiacum Bicknell.
Scarlet-fruited Horse-Gentian. Keeler, Van Buren Co., H. S. Pepoon.
Tunica Saxifraga Scop.
Escaped from cultivation, Mrs. Ralph Ballard, Niles.
Utricularia biflora Lam.
Two-flowered Bladder-wort. Silver Creek, Van Buren Co., H. S. Pepoon.
Vaccinium atrococcum (A. Gray) Heller.
Black Blueberry. Keeler, Van Buren Co., H. S. Pepoon.
Verbesina alternifolia (L.) Britt.
Ypsilanti, O. A. Farwell; Ann Arbor, S. Alexander.
Vernonia Illinoensis Gleason, *V. grandiflora*, O. A. Farwell.
Vernonia Noveboracensis (L.) Willd.
Detroit, O. A. Farwell.
Vibernum dentatum L.
Arrow-wood. N. Keeler, Van Buren Co., H. S. Pepoon.
Washingtonia divaricata Britt.
Thunder Bay Island, Alpena Co., C. K. Dodge.

PLEISTOCENE BEACHES OF SAGINAW COUNTY.

BY

W. F. Cooper,

Michigan Geological Survey.

CONTENTS.

Introduction.

For an account of the Glacial Geology of the "Southern Peninsula of Michigan," the reader is referred to an article by F. Leverett in the Sixth Report of the Michigan Academy of Science, 1904, page 100. During the present year the same author has prepared the report on the Glacial Geology of the Ann Arbor Folio, No. 155 of the U. S. Geological Survey publications, in which will be found a general summary of the glacial geology of the Lower Peninsula. Prof. James W. Goldthwait of Northwestern University, Evanston, Ill., has prepared Bulletin 17 for the Wisconsin Geological Survey in which will be found an excellent historical and geological review of the Pleistocene Lake History down to 1906. For a general account of glacial geology those interested in this subject would do well to read Chapter XIX on the Pleistocene in Volume III of Chamberlin & Salisbury's Geology, printed in 1906.

Centers of Ice Radiation.

As far as the geology of Michigan is concerned we only have two centers of ice accumulation and dispersal to deal with, namely the Keewatin ice sheet in central Canada and west of Hudson Bay, and the Labradorean which takes its name from the peninsula of that name in eastern Canada.

During the advances and retreats of these great continental glaciers there have been separated six epochs of glaciation beginning at the bottom as follows: Jerseyan, Kansan, Illinoian, Iowan, early and late Wisconsin. In the intervals of deglaciation are found early indications of soil deposits be-

tween the different sheets of drift all of which have been given a nomenclature and it furthermore seems probable that some of these intervals of glaciation exceeded in time, the period since the last glacial epoch closed.

Radiating from these ice masses there are along the southern border of the last glacial epoch a more or less pronounced lobation of the ice. Thus in the area of Lake Superior the Keweenaw and Superior lobes were developed; along the axis of Lake Michigan the Green Bay and Michigan lobes; in the Huron-Erie basin the Saginaw lobe and the Huron-Erie lobe.

Lake History.

As the ice border withdrew to the north the glacial waters were ponded between the ice on the north and land divide to the southward. The history of these changes has been described by Chamberlin and Leverett in the reports referred to above. In brief, we first have Lake Maumee imponded by the Erie lobe and escaping through the lowest available col at Fort Wayne, into the Wabash, and thence to the Gulf. In the second stage of Lake Maumee consequental to the further retreat of the ice we have the waters draining off through the Imlay outlet in the eastern part of Lapeer county, around the edge of the Saginaw ice-lobe to the valley of the Grand River. Somewhat later Lake Saginaw came into existence, coincident with the retreat of the Saginaw glacier and this crescentic lake drained off through the Pewamo passage into the Grand River outlet, and thence through Lake Chicago and the Illinois route into the Mississippi. During a portion of the existence of this Lake Saginaw we have Lake Maumee still discharging through the Imlay outlet into Lake Saginaw but later on in the retreat of the ice, a lower outlet across the "thumb" of eastern Michigan was opened and the Imlay outlet was abandoned.

Later on we have Lake Arkona with the Belmore beach and Lake Whittlesey the resultant of the readvance of the ice, discharging through the Ubly outlet, and for a time submerging the Arkona beaches which were partially obliterated. At a still later stage Lake Warren came into existence, contemporaneous with the withdrawal of the ice from the "thumb" and allowing the waters of Lakes Saginaw and Whittlesey to unite. At first the drainage was westward through the Grand River valley until the ice retreat to the eastward furnished a drainage channel through the Mohawk valley.

At a still later date Lakes Algonquin and Nipissing came into existence consequental to the further withdrawal of the ice. The area of Lake Nipissing was very nearly coextensive with that of the present area of the Great Lake System.

Beach Formations.

During the summer and fall of 1899 and a portion of field season of 1900, the writer had an opportunity of obtaining detailed information concerning beach formations, which were in course of development during the history just sketched. In the summer of 1904 and 1905, Mr. Charles Holmes, formerly County Surveyor of Saginaw, ran 1339 miles of levels with the wye level and this has given a fine chance to determine the elevation of numerous old beach formations with accuracy. In the following account Mr. Holmes' elevations are indicated by a decimal point while my readings taken with a good aneroid barometer are only given for feet. In making aneroid adjustments a graph was determined giving the amount of variation of the instrument in feet per minute, from which the necessary correction could be made.

In this connection it is necessary to state that Mr. A. C. Lane did the field work in R. 4 E., Tp's. 10-13 N., R. 5 E., Tp's. 12, 13 N., and a portion of T. 10 N., and all of T. 12 N. This includes much of the lower areas of Saginaw county and consequently a very considerable portion of the Lake Nipissing history which is only partially included in this account. The different beach formations will be designated by their elevation above sea level, or above tide (A. T.) and I have attempted to classify them according to that base.

702–715 foot beach.

This beach is well developed in the southern part of Saginaw county near the county line in T. 9 N., R's 1, 2 E., and the elevation as determined by Mr. Holmes in the S. W. ¼ of Sec. 34, T. 9 N., R. 1 E. was from 702.8 up to 714.8 and 714.9 A. T. In Brady, T. 9 N., R. 2 E., the following elevations were obtained with the aneroid and level.

Section	31,	east line,	715 A. T.
"	33,	north "	716 A. T.
"	35,	" "	720 A. T.
"	31,	N. E. ¼	715.9 at top.

In Mt. Forest township, Bay county, T. 17 N., R. 3 E., there is a well developed beach at an elevation of from 720-734 with which this may correspond. Whether this is one of the Upper Grassmere or Lower Forest Beaches has not been determined. This may be one of the beaches noted by Mr. Lane in his Huron county report from 729 foot up.

680 foot beach.

In Lane's Huron county report we have the bottom of the Grassmere beaches given an elevation of 680 feet A. T. In Bay county there is a well developed beach near Mt. Forest station having a height of from 675-690 A. T., bottom and top. In Saginaw county and on the north line of Section 22, T. 9 N., R. 1 E., we find a former shore line 683 ft. A. T. at the top. In T. 11 N., R. 1 E. we have the following readings.

Section	9,	S. E. ¼,	684.8 at top.
"	10,	S. E. ¼,	684.3 " "
"	9,	N. E. ¼,	686.8, 687.3.
"	9,	S. W. ¼,	687.3 top.
"	5,	T. 11 N., R. 2 E.,	683 at top.

651–665 foot beach.

With the next halt in the lowering of the lake level is found a well developed beach in the western and southern part of Saginaw county. In Chapin, T. 9 N., R. 1 E. the following determinations were made.

Section	4,	N. E. corner,	651.5–664.7,	bottom and top.
"	5,	west line	664.8,	top.
"	20,	" "	665.3,	"
"	8,	north "	661	"
"	17,	west "	661	"
"	9,	east "	662	"
"	14,	" "	663	"
"	16,	" "	664	"

In Marion, T. 10 N., R. 1 E. the following determinations were made.

Section 33, east line, 662 top.
" 16, " " 663 "
" 9, north " 663 "
" 9, " " 652.4–663.3, bottom and top.
" 33, east " 664, top.
" 27, " " 665.
" 32, county " 665.
" 28, north " 666.
" 21, " " 669.
" 22, " 660.3–670.8.

In Brady, T. 9 N., R. 2 E. the following elevations were obtained.

Section 14, north line, 664 top.
" 11, east " 666 "
" 19, N. E. ¼ 666.6 "

In Tittabawassee, T. 13 N., R. 3 E. and northwest of Saginaw this beach is again picked up where it is deployed on the Saginaw-Port Huron moraine,

Section 4, north line, 664 top.
" 10, " " , 664 "
" 10, " " , 649–664 bottom and top.
" 10, east " , 664 top.
" 5, north " , 659–665 bottom and top.

In Richland, T 12 N., R 2 E. this abandoned shore line has been identified on the east side of section 29, elevation 665 and on the east side of section 33 where the elevation is 649.2–665.3, bottom and top.

This beach has been traced in Garfield township, Bay county, T 16 N., R 3 E. and has been reported on in the Bay county report, in the annual of the Michigan Geological Survey for 1905. This beach is apparently most nearly connected with the Elkton beach described by Lane in the Huron county report.

647–654 foot beach.

Closely connected with the preceding beach formation is found another abandoned shore line in the southwestern portion of Saginaw county in Marion, Brady, Chesaning and Maple Grove townships.

In Marion, T 10 N., R 1 E. this beach formation has been identified at the following localities:

Section 27, east line, 647.4–654.3, bottom and top.
" 13, north " 653, top.
" 35, " " 654, top.
" 34, east " 653.1 top.

In Brady, T. 9 N., R. 2 E. and southeast of Marion township this shore line is again apparently found on the north line of Section 17 at an elevation of 657 feet at the top. In Chesaning, T. 9 N., R. 3 E. the following locations are given.

Section 13, east line, 653.5 top.
" 7, west " 654 "
" 18, north " 657.3 "

In Maple Grove, T 9 N., R 4 E. and to the eastward of Chesaning is found a beach on the east line of Section 18 at 659 A. T. at the top.

This abandoned shore line corresponds almost exactly with the elevation of the Elkton beach as given by Lane in the Huron county report. In Bay county to the northward this former shore line is found in Williams, Beaver and Garfield townships at an elevation of from 644–654 feet A. T., bottom and top.

633–645 foot beach.

This beach is found generally deployed in Saginaw county as will be seen by referring to the following tables.

In Marion, T. 10 N., R. 1 E. Mr. Holmes obtained the elevation quite accurately on the east side of Section 35 where the height is from 633.8–645.3 A. T., bottom and top.

In Brant, T 10 N., R 2 E. the references to this beach are not so satisfactory, and in fact correspond in a way to the irregularities of beach formation in Bay county at this elevation.

Section	33, south	line,	627.9–638.3.
"	17, north	"	639 top.
"	18, "	"	640 "
"	33, "	"	640 "
"	19, "	"	631.7–643.3.
"	20, "	"	623.2–644.3.
"	18, S. W. ¼		643.3.
"	18, S. W. ¼		644.3.

In Richland, T 12 N., R 2 E. these elevations were obtained.

Section 33, S. E. ¼, 644.8, 647.3 top.
" 27, N. E. ¼, 648.3 top.
" 27, ¼ line, 636.5–648.3, 649.
" 3, east line, 646.
" 27, " " 649.

In Thomastown, T. 12 N., R. 3 E. this beach is found at substantially the same elevation.

Section	7, east	line,	642.
"	6, "	"	642.
"	17, north	"	646.3.
"	18, west	"	646.
"	8, S. W.	¼,	646.3.

In Tittabawassee, T 10 N., R 3 E. we get it again on the east line of Section 6 at 644 feet A. T., at the top. In Maple Grove, T. 9 N., R. 4 E, and on the east line of Section 8, Mr. Holmes made the elevation of this former shore line 643.3 feet A. T. In Taymouth township, T 10 N., R 5 E. the following references are given.

Section 24, , 646 A. T.
" 35, N. E. ¼, 636.3.
" 36, west half, 636.3, 640 top.
" 35, S. E. ¼, 639, 640.3. top.

In Bridgeport, T. 11 N., R. 5 E. this beach is found on the east line of Section 14; 642.6 A. T. at the top. In Birch Run, T. 10 N., R. 6 E. and on the west line of Section 12 we have a beach at 641.6—649.3 feet A. T., bottom and top. In T. 11 N., R. 6 E. the following references are somewhat doubtfully given.

Section 18, S. E. ¼, 640.3.
" 18, S. W. ¼, 642.3.

In Blumfield, T. 12 N., R. 6 E. and on the Tuscola county line there is a gravel ridge at an elevation of 642.5 feet A. T. at the top.

618–635, 639 foot beach.

In Brant, T. 10 N., R. 2 E. this well marked shore line occurs as follows:

Section	27,	630 at top.
"	15, ¼ line,	631.
"	35, north line,	632.
"	35, south "	633.
"	13, N. W. corner,	634.
"	35, north line,	634.
"	15, ¼ line,	635.

In Fremont, T. 11 N., R. 2 E. equals 638 feet A. T. at the top on the north line of section 2.

In Richland, T 12 N., R 2 E. are a number of locations for this beach level.

Section	34, S. E. ¼,	635.9 top.
"	25, N. W. ¼,	637.3.
"	14, east line,	627–635, bottom and top.
"	35, " "	629–636.
"	13, north "	636.9, 637.3, top.

In Chesaning, T. 9 N., R. 3 E., in the southern part of the county this beach is again found.

Section	5, north line,	630 A. T., top.
"	12, " "	631.
"	6, " "	632.3.
"	10, east "	633.

Thence northward from here in St. Charles, T 10 N., R 3 E. as follows:

Section	32, north line,	632 top.
"	31, south " ,	628.4–639.3, bottom and top.

In Thomastown, T. 12 N., R. 3 E.

Section	15, north line,	618.1–635.3, bottom, top.
"	7, " " ,	635, top.
"	18, west line,	638, top.
"	20, S. E. ¼ ,	630.8 top.

In Tittabawassee, T 13 N., R 3 E.

Section 13, north line, 639 A. T. top.

In Taymouth, T 10 N., R 5 E.

Section 24, east line, 634, top.

Thence going northward again into Bridgeport, T. 11 N., R. 5 E. this beach is found at an elevation of from 619–631, bottom and top, in Section 23.

Southeast of Bridgeport, in Birch Run, this beach is found on the north line of Section 11, T 10 N., R 6 E. at an elevation of 638 feet A. T., at the top.

In the Bay county report this shore line was designated the Saganing beach. It is also described by Lane in his Huron county report.

Algonquin and transition Beaches.

In Saginaw as well as in Bay county we have apparently two old shore lines which represent halts and shore formations in the recession of this body of water. In the Bay county report this upper Algonquin beach has an elevation of from 610—623 feet A. T., bottom and top, while the lower built up beach ridge is from 593—610 feet A. T. The cut beach of the lower Algonquin in Bay county has an elevation of from 597—602, bottom and top. In Saginaw county this upper Algonquin beach, if such it proves to be, is more strongly and irregularly developed than in Bay county, while the lower beach is relatively undeveloped here in comparison with that shore line in Bay county. In the southern part of Bay county this lower Algonquin beach is less strongly developed than in Bay City, and thence north from there. The following elevations are here given for what may represent an Upper Algonquin beach in Saginaw county.

In Brant, T. 10 N., R. 2 E., as follows:

Section	23,	north line,	616,	top.
"	22,	east "	, 616,	"
"	15,	" "	, 617,	"
"	28,	" "	, 617,	"
"	20,	" "	, 617,	"
"	23,	" "	, 620,	"

The levels from Mr. Holmes give a much better differentiation for this township.

Section	24,	S. W. ¼,	621.3,	top.
"	24,	S. E. ¼,	622.9,	"
"	23,	S. E. ¼,	614.9–622.3,	bottom and top.

Thence north into Fremont, T 11 N., R 2 E. there are the following elevations determined by Mr. Holmes.

Section	34,	east line,	624, A. T., top.
"	11,	" "	625.3.
"	10,	" "	626.
"	1,	" "	628.

Other determinations made with the wye level in this same township show beach formations at 611.3, 614.3, 617.3, 617–619, A. T., at the top and it is quite probable that at least a portion are to be referred to a lower, more or less permanent elevation, of beach formation.

In Richland, T 12 N., R 2 E. there is a beach having an elevation of 624 feet A. T. at the top.

Thence south and east into St. Charles, T 10 N., R 3 E. we get the upper Algonquin well defined from the lower beach at the following elevations:

Section	19,	S. W. ¼,	611.9–616.8, 620.3,	bottom and top.
"	30,	N. E. ¼,	617.8,	top.
"	33,	S. W. ¼,	618.3,	"

Thence north again into Thomastown, T 12 N., R 3 E. we again get beach formations at irregular elevations.

Section	33,	east part,	606–614, bottom and top.
"	24,		617, top.
"	27	state road,	603.0–617.3, top.
"	4,	east line,	620, top.
"	3,	north "	621, "

Section 30, east line 610–622, bottom and top.
" 30, east " 615–623, " " "

The following determinations were made by Mr. Holmes:

Section 4, N. E. ¼, 623.3, 625.8.
" 33, S. E. ¼, 600.9–613.3 and 625.3. Apparently two beach formations.

Section 6, N. E. ¼, 625.3, top.
" 10, S. E. ¼, 626.3, "

In Tittabawassee, T 13 N., R 3 E. and along the river road in Section 17, there is a beach having an elevation of 622 feet A. T. at the top.

Thence south and east again into the tier of townships next adjoining is found in Section 6 of Maple Grove, T 9 N., R 4 E., and northeast of the center, a beach at an elevation of 616 feet A. T. at the top.

In the S. W. ¼ of Section 6, T 11 N., R 4 E. is found a beach formation comparable to the one in Section 33, Thomastown having a height of 613.3 feet A. T. at the top. and probably referable to the lower Algonquin beach formation.

In Taymouth, T. 10 N., R. 5 E. we have:

Section 21, east line, 624, top.
" 24, " " 627.
" 18, west " 626.

There is also another set of beaches with an elevation at the top of from 611–615′ A. T. Mr. Holmes gives beach determinations in this township as follows:

Section 4, north, ½, 614.3–615.8, top.
" 4, S. E. ¼, 616.8.
" 10, N. W. ¼, 617.3.
" 3, N. E. ¼, 620.3.
" 2, N. W. ¼, 620.3.
" 10, N. W. ¼, 620.3.
" 12, N. E. ¼, 625.3.

In Bridgeport, T. 11 N., R. 5 E. there is again suggested a slightly developed beach, lower than the highest Algonquin beach in Bay county, and higher in elevation than the normal altitude of the main lower beach of that area. This intermediate beach is also fairly well defined in the area under consideration.

Section 35, 617, top.
" 23, north line, 623, "
" 34, 624.
" 24, cemetery, 624.
" 24, north line, 625.

Coming down to the lower Algonquin beach which has in Bay county an elevation of from 593–610 feet A. T., bottom and top, the following observations are available in Brant, T. 10 N., R. 2 E.

Section 2, north line, 608, top.
" 13, ¼ " 608, "
" 25, N. E. ¼ 614.3, "

In Fremont, T 11 N., R 2 E. we again get a beach intermediate in height between the lower and upper beaches on the north side of Section 1 at an

elevation of 617 A. T. at the top. In the N. E. of Section 25, Holmes determined the elevation of a beach having a height of 606.3 feet at the top.

In St. Charles, T 10 N., R 3 E. are the following elevations for the top of this beach.

Section	18, S. W. ¼,	607.3,	top.
"	18, N. E. ¼,	607.3,	"
"	18, state road,	607.3,	"
"	22, ¼ line,	607	"
"	17, ¼ "	608	"

In Swan Creek, T. 11 N., R. 3 E. there are the following data:

Section	9, north line,	608,	top.
"	19, " "	613.4	"

Thence north again into Jamestown, T. 11 N., R. 3 and 4 E.

Section	5, cemetery	606,	top.
"	7, north line,	608,	"

In Thomastown, T. 12 N., R. 3 E.

Section	11,	612,	top.
"	35, N. E. Corner,	606,	"
"	35, N. E. ¼,	601.5–610,	bottom and top.
"	35, S. W. ¼,	605.8,	top.

Thence east and south into the next range of townships are the following elevations in Taymouth township.

Section	21, east line,	611,	top.
"	3, " "	612.	
"	10, north "	603.–615,	bottom and top.

In Bridgeport, T. 11 N., R. 4 E.

Section	31, east line,	606,	top.
"	31, " "	607.9,	"

Nipissing beach.

What may prove to be beach formations belonging to this stage of lake elevation are given below.

In St. Charles, T 10 N., R. 3 E.

Section	26, north line,	597 feet A. T.,	top.
"	15, S. W. ¼	592.3 and 595.5,	"

In Jamestown, T. 11 N., R. 3 and 4 E.

Section	1, east line,	600 feet A. T.
"	6, " "	601 " " "
"	2, west "	601 " " "

In T. 11 N., R. 4 E. Mr. Holmes gives the following elevations.

Section	24, N. E. ¼,	597.8, 599.8, top.
"	36, N. E. ¼,	600.3.

In Bay county the Nipissing beach is represented as having an elevation of from 587 feet A. T. at the bottom to 593, 598 feet at the top. In Huron county Lane makes the elevation 594 feet at the top.

Lansing, Michigan, March 30, 1908.

SOME POSSIBILITIES OF PEAT UTILIZATION.

CHARLES A. DAVIS.

For many years now, especially since the strike of the Anthracite coal miners in 1902–3, when actual fuel famine existed in most cities, and much of the country where anthracite is the principal domestic fuel, the attention of those who are familiar with conditions existing in Northern Europe, has been turned to peat as a possible undeveloped source of fuel supply.

The agitation of the subject has now gone so far that it may be said that there is a peat question, which, from the view-point of American economics may be stated as follows: "Can the extensive beds of peat which are found widely distributed over the country, especially in those parts remote from the chief centers of coal supply, be used profitably for fuel at present. If not, are they available for other purposes?"

For the proper discussion of this question it is necessary to have very clearly in mind, not only the existence of peat in sufficient quantity and of good quality for the uses intended, and the desirability of its being turned to account, but also the numerous other factors, practical, economic, and even psychological, which must be taken into consideration before a definite answer can be obtained.

While there is little opportunity in this place for considering the purely historical, some attention must be given to the history of the development of the utilization of peat in other parts of the world, if a fair start is to be made in this country, and the advantage is to be taken of the work, and the mistakes of others already well-advanced in ways of handling peat.

From time immemorial, cut peat, air-dried, has been used as fuel for domestic purposes in Northern Europe, and more recently in compacted forms, has been used, with considerable success as the source of energy for steam production on a large scale, the beginnings of experiments in this direction probably dating back to the early stages of the use of the steam engine for manufacturing purposes.

Even before the use of peat for the generation of steam, however, much experimental work had been carried on to make a better product than cut peat, and this resulted in the gradual development of machinery for drying peat, for grinding it while still wet, to make it more plastic and compact, and for molding it into blocks of regular size, thus making a more uniform and efficient product, which could be produced in larger quantities more certainly than cut peat.

These developments were largely made in Germany, a country always ready to investigate thoroughly any natural resources within her borders and develop them, to the greatest possible extent by careful and methodical research, and where, at the present time, studies of the possibilities of peat are still being pushed forward with energy.

With the greater demand for fuels which came with the increased use of the steam engine, and the industrial awakening in the Northern European countries, which has taken place in the past twenty-five years, renewed efforts were made to increase the efficiency of peat as a fuel, largely because other types of fuel were scarce and expensive.

The primary difficulty in using peat for fuel, lies in the great amount of water which it contains, and the slowness with which this disappears, even when the peat is placed in a dry place. This is due to the fact that the plant cells and tissues which make up the peat, hold the water, not only in the cavities of the cells themselves, but in their walls as well, and give it up very slowly, and only by evaporation, yielding but a small per cent of the total amount of water under pressure.

These facts, however, were only learned in Europe, after long-continued and expensive experimentation, costing in the aggregate millions of dollars. Through a period of years, attempts were made to get quickly rid of the water in peat by filtering and pressure, both by the application of vacuum and hydraulic pressure, reaching tons to the square inch, and also by the use of centrifugal machines, but, while the history of these attempts is of great interest, it cannot be entered into here at any length.

Nor can an account be given of the efforts made, and the machinery devised, to rapidly and thoroughly dry peat, as it was dug, by the direct application of heat generated by the use of fuel of various types, for, if this were done, there would be time for no other discussion. It is, therefore, perhaps sufficient to say that the best and most conservative students of the European peat fuel industry all agree that, up to the present time, no financially successful process of drying wet peat by the application of artificial heat has been discovered, and the only feasible way for accomplishing this is that which was first used, namely, exposure to the heat of the sun and air.

The reason for this has been summed up fully in the statement that three tons of dried peat, or its equivalent in heat units, are required to produce one ton by this method, so that, even where fuel is to be had for the cost of handling, as is the case of the refuse peat taken out of the bog, this cost is prohibitive. This is apparent when it is remembered that, even if the refuse is used in a partly-dried condition, a ton of fuel can only be obtained at the cost of digging and drying five or six tons of wet material, until it is free enough from moisture to burn.

Moreover, it is also well known that the higher the water content of any fuel, the less its efficiency when burned; thus, peat waste, having from 25 to 50 per cent of moisture, is reduced in fuel value, compared with the same material, perfectly dry, somewhat more than one per cent of the total number of heat units which could be developed from it, for every per cent of water which it contains.

Thus, giving dry peat a fuel value of 100, that with 25 per cent water has an efficiency of 72, that with 30 per cent moisture but 63, and that with 50 per cent water only 41 per cent of the fuel value of the perfectly dry material. It is, therefore, apparent that the amount of heat developed by one ton of the perfectly dry peat, can only be obtained by using a ton and a quarter, a ton and a third, and a ton and six-tenths of that which has 25, 30 and 50 per cent moisture, respectively, hence the amount to be handled both on the bog, and at the furnaces, is increased in direct proportion, and the cost of the artificially dried peat, instead of being three tons, has been increased to three and three-fourths, four, or even nearly five tons of material to be produced, according to the water content, and this excess must be charged to the cost of production, to which, also, must be added the cost of putting the dry peat on the market, and other fixed charges.

Still other efforts to improve the quality of peat, and to make it more transportable, are those directed to convert it into charcoal, or coke, and, while the problem of doing this successfully has been a complicated one,

it seems to have been attacked with great earnestness, because of the desirability and value of the product. Most encouraging reports of its complete solution on a commercial basis reach us from Russia and Germany, where the Ziegler process of making peat coke seems to have gone beyond the experimental stage.

To sum up then: In Europe, extensive and very thorough study, and a large number of experiments have been made, to produce an efficient and easily transported fuel from peat (1) By grinding and compacting, while wet, and drying in the air, (2) By drying artificially and briquetting in the dry state, (3) By taking the product of either of these processes and heating it in ovens, or in closed retorts, until the volatile matter is driven off, i.e., making charcoal or coke of it.

The work of development has gone farther than this, however, and mention should be made of the use of peat as a source of gas for illumination and power, its use in paper making, in the weaving of fabrics of various sorts, its extensive use as litter for stables and barns, an increasing use as the basis of stock food, for sanitary purposes in towns and cities, as a constituent of artificial fertilizers, and, by no means of least importance, the great improvement which has been made in the agriculture of the peaty soils by drainage and proper cultural methods, so that great areas, formerly considered untillable, have now become productive.

This brief sketch of the development of the utilization of peat as fuel and for other purposes has been made, not only to enforce what has already been said by others along the same line, but also with the special purpose of urging upon the attention of prospective investors, or inventors, the folly of commencing at the very beginning in this country, and trying to develop new processes and new machinery for handling peat, for any purpose, until a careful study has been made of the processes and machines which have been tried and are now in use in Europe. These may be faulty, and some of them admittedly are so, but they represent much careful and exhaustive study of the problems involved, and the expenditure of much time and more money, as well as the sum of the experience of practical men, actually working on the material on a commercial basis, and to ignore this storehouse of experience and knowledge, is to handicap the development of our peat resources beyond the limit of tolerance. That this has, in a measure, been done, however, is beyond question, and not a few of the failures of the attempts which have been made in this state to establish peat fuel plants may be directly attributed to this cause.

The amount of peat available for various purposes in this state is undoubtedly very great; as yet, in fact, we have little basis for even an approximate estimate of the quantity, but, assuming that even half of the swamp lands of the country are covered by peat suitable for fuel, and that this has an average depth of ten feet, the amount of fuel alone which is stored up in this way, amounts to billions of tons.

Moreover, these deposits of peat are widely distributed over the greater part of the eastern half of the continent, and, doubtless, over the moister parts of the western half as well, and there are notably widely-spread deposits in those regions so remote from supplies of coal, that the price of this commodity is sufficiently high to tempt capital to develop the peat, if it can only be shown that it is a practicable thing to do.

The history of the attempts at such developments, however, is not encouraging, when one goes over the field and enumerates the plants which have been built, run for a brief period, and then closed down indefinitely,

without having marketed a ton of fuel with profit. It is not necessary to give a list of these experiments here, for, after a careful enquiry throughout the country east of the Mississippi, during the summer of 1907, the writer found but a single place where peat fuel was to be had as needed, namely, of the Commercial Artificial Fuel Company of Toledo, Ohio, whose plant was running and who were ready to contract to furnish a good quality of peat fuel in lots to suit the purchaser, at a reasonable price.

If the problem of developing an industry, or a number of industries from the peat deposits of the country is to be solved in a satisfactory way, it must be borne in mind that peat is not a single, simple substance, always uniform in all of its properties, but one which is not only very variable in characteristics, over wide areas, but which also may vary in a marked degree in the same deposit. In fact, variability must be expected in the mo t common type of bog, because of the way in which the peat has been formed, and throughout the region where peat deposits are most numerous, it is rather rare to find the material of the same structure from top to bottom of the beds, and in the very deep beds, this is still rarer.

The variations in the properties of peat are both physical and chemical, and are of such nature that they cannot be considered here in detail; but, in general, it may be pointed out that peat varies from light brown to black in color, from the texture of a loosely felted fabric to a compact, solid substance, nearly like lignite or coal when dry, and varies as greatly in weight and plasticity, cohesiveness and in fuel value, as in other properties; it is probable that there are some definite relations between these variations in many cases, but not in all, by any means, and the reason for calling attention at all to them here is to point out the fact that no single industry can use all kinds equally well. For example, some types of peat, though low in ash, and having a high fuel value, are so light in weight, so poorly decomposed and so unplastic, that they make a very bulky, friable, and quick-burning fuel, which cannot be shipped any distance, or handled without much waste. Such peats, at best, are hard to work, and it is doubtful if they should ever be used for any except most local markets for fuel, and if a deposit of such peat is made the basis of large investment, for the purpose of developing a fuel industry, to supply distant markets, it is almost certain to fail to meet the anticipations of its projectors.

On the other hand, such peat might well meet the requirements of some other industry, in an almost ideal way, and be profitably worked from the beginning of the enterprise.

One of the most potent reasons which has appeared to account for the failure of the many attempts to establish a peat fuel industry in this country has been the apparent ignoring this primary fact, namely, that the peat selected for exploitation was not adapted to the purpose for which it was decided to use it, nor to the type of machinery which was installed for its manufacture. Errors of this sort, however, are such as are likely to beset the path to success in any new and untried field of industry, and, while causing much discouragement and some serious financial losses, serve to stimulate the more persistent to renewed and more carefully directed efforts, and, at the same time, act as beacons to warn later comers to proceed more thoughtfully, if they would safely pass over such dangers.

Fundamental questions at this stage of the discussion should be: Are there opportunities in this country, such as occur abroad, to develop industries based on the utilization of peat as raw material? Are the conditions such that this material which occurs so widely spread and in such quantities,

can be properly used in competition with equally good, or better, substances already in use, and now holding the markets?

Considering it as a source of fuel supply, its most obvious use, and doubtless, that first to occur to the minds of most people as the one most likely to be successful, what are the opportunities and the possibilities and probabilities of success? At first thought and with but casual investigation of the matter, it would seem as if opportunities were practically as wide as the field over which fuel of any sort is used, and that peat has but to be made ready to use, and at once the demand for it will become general.

On more careful study of existing supplies of other fuels, and of the methods of distributing and handling these, however, one is led to the inevitable conclusion that for a long time to come, the larger markets will be chiefly supplied as they are now. This is a country of an abundance of good coal, which is to be had at moderate prices, over the greater part of the more thickly settled regions, and in the manufacturing districts. The trade in coal is so thoroughly organized, moreover, that a new type of material, competing with it, must necessarily make its way slowly, and especially will this be true of peat, which, at its best, must always be handled rather carefully and always be transported and stored under cover, in order to prevent loss or deterioration, and which is at the same time much more bulky than coal and a poorer fuel as well.

Aside from these factors, are some which may affect the would-be provider of peat fuel even more, namely, those arising from the consumers, such as a prejudice, which the average human being has against using a new thing, as a substitute for that which he knows and likes, or, the fact that furnaces, grates and other heating appliances are all devised for the use of coal, and would need some changes in order to get the best results from any other fuel. Not the least potent with the larger consumers, at the outset, would be the fear that once having adopted peat fuel, they might be unable to secure a constant supply. It is a well-known fact that some large industrial concerns, for example, carry at least a full year's supply of coal, as a reserve stock, and often have more than this available. From these and other causes, which could be mentioned, the prospects for founding a great peat fuel industry, which should soon be an active competitor with the coal trade are not good.

On the other hand, there are evidently innumerable opportunities in the direction of slow development of small, inexpensive, and carefully planned plants, equipped to supply limited local markets with fuel, for domestic uses or small manufacturing enterprises. There is opportunity for the utilization of peat for fuel in larger quantities, in regions remote from coal fields, like those lying west of the Great Lakes, and about the head of the Mississippi, as well as in Florida, and the adjacent regions, where coal is not only poor, and high in price, but wood also is of poor quality, and hard to get. In these regions, there are calls for fuel, which well-planned and carefully executed peat fuel developments would doubtless meet, and in them lie some of the most promising fields for the upbuilding of a large industry, based on the peat beds. Not only this, but the converse is true, that unless the peat beds of these regions are used for fuel, several promising industries have reached the limits of their expansion, although but recently established.

In still other directions, opportunity lies open for rightly directed effort, namely, in furnishing either charcoal, coke, gas, or all of these, or even electric energy, from peat beds of large extent, which lie sufficiently near industrial

centers to make the demand for such development large enough to warrant an expenditure of the capital necessary to establish plants for these purposes.

The advantage of these forms of working up peat deposits, over those looking to transforming them into crude forms of fuel are obvious, but, since they are untried as yet, or only in the early stages of development abroad, it will be necessary to proceed carefully through experimental stages before larger expansion can be expected.

Of the possibilities of a peat coke, or charcoal industry, there is a large opportunity opening up extended vistas, which, seemingly, have no limits, since the demand for such a product as the coke must constantly increase, as the rapidly diminishing hard-wood forests are drawn on more and more for materials which must cause a decrease in the supply of wood charcoal, now used so extensively for metallurgical operations, and for which the peat coke is especially adapted.

It is remarkable that some of the more progressive iron mining companies, owning as they do, extensive tracts of swamp land, covered by good peat, in Northern Michigan, Wisconsin and Minnesota, have not as yet erected experimental unit plants and begun the work which some of their progressive men already realize must soon be done. That they are making preliminary enquiries and watching the foreign peat coke developments is known, and at any time we may learn of the beginnings of an enterprise of this sort in our northern peat bogs.

In a small way, peat charcoal has been made in Connecticut, experimental work is being conducted in Massachusetts, and, although the success of these experiments has not been made public, they are the forerunners of an attempt to grasp a tempting opportunity to supply a large demand for a good substitute for wood charcoal, for domestic uses, now a scarce article. It is to be hoped that, before long, we may learn that whatever difficulties have been encountered in the e experiments are overcome, and the making of peat charcoal is a commercial success.

Much has been written of the possibilities of peat as a source of gas for illumination and power purposes, especially the latter, and again it is true that most of the work which actually has been done has been carried on abroad, with the notable exception of the recent experiments on peat as a source of gas in the producer gas engine, which were made by the Technologic Branch of the U. S. Geological Survey in its Fuel Testing Plant at St. Louis, and which were extended at the Jamestown Exposition. These trials gave highly interesting and significant results, and, if confirmed by later work on a more extensive scale, will open up much greater opportunities for the use of peat fuel than any other which has been considered, since, used in this way, the peat has nearly the value of coal, as the gas procured from it was equal to that given off by equal weights of coal of certain grades, and as efficient in producing power.

As the producer gas engine is being rapidly improved in various ways, and increased in size and power, and is also almost as rapidly displacing the steam engine as the motive power for many industries, this opportunity for peat utilization is not to be under-estimated, and its possibilities to the prospective peat fuel manufactures are very great, because, according to present lights at least, the peat, to be successfully used in the producer gas engine, must be machined and dried.

In considering the neglected opportunities which are offered by peat as a fuel, that presented to the small manufacturer by any of the numerous peat bogs which lie beside the railroads throughout a large part of our northern

country, and are not wanting in the south, should be mentioned. Many of these would furnish what would be practically an inexhaustible supply of fuel, at a very low cost, to a manufacturing plant located on their borders, the chief cost being that of installing the machinery for preparing the peat, after which the only expenses would be those incidental to harvesting the fuel. At one place visited by the writer not long ago, a small factory was located, almost ideally on the edge of a large, fully cleared deposit of excellent peat, but using coal shipped several hundred miles by rail.

A word regarding the causes to which may be attributed, in part at least, the failure of the many of the peat fuel plants which have been started, aside from those already mentioned. The most potent cause for the failure of some, aside from those inherent in the process itself, has been the adoption of the briquetting process, with peat which was not adapted to such a process. In other cases, perhaps the majority, bad arrangement of the plant has contributed much to the lack of success. It has not seemed duly to impress the builders of such plants, that in handling wet peat, freshly dug from the bog, there was nine times as much water as peat thrown out, moved about, and carted to the factory, and often there is no definite arrangement for conveying the wet material which was dug, to its destination, except wheelbarrows or carts. By such arrangements the cost of production per ton of dried fuel is raised far above what it should be, considering the possible price after it is dry.

Another cause of failure has seemed to be the lack of a provision of sufficient drying space and proper division of the work. Similar to these difficulties were the attempts made with presses which were too large for the rest of the equipment, so that just as the press was running nicely, the supply of peat would give out and all hands would be obliged to go out after more, and, in the meantime, the press would stop, the steam go down, and, when a new run was begun, there would be tedious and costly waits before the machinery would run smoothly again.

Other causes, such as distance from railroad station, lack of knowledge and experience on the part of the owners, and too small capital to carry the plant through the experimental stages of development, have been operative, but those first mentioned are the ones most manifest to the casual observer. The remark of a shrewd business man, when asked by the writer not long ago if a peat fuel factory in his neighborhood was a success, is to the point: He said "He didn't know about the success, but he didn't think much of a business which took all the week to make enough product to take to market on Saturday in a two-horse wagon."

The opportunities for the development of other than the fuel industry from our peat bogs, seem to be even greater than those which lie in that direction. Already there is a peat paper factory in operation, with an assured output of a superior grade of paste-board, which is sold far ahead of the present time. The manufacture of peat litter as bedding for stables is also established in at least one place in Indiana, and the bogs where other factories might be located are numerous, in various parts of the country, and, judging from the reports which are given by those who have used this material, it is superior to all others now in use for this purpose. It should, in these days, find a ready sale to dairy farmers, and to horse owners in cities, to help them keep down the odors in their barns, as it is an efficient deodorizer, besides being cheaper and better bedding than straw.

Another growing industry based on peat, and one which has thus far proved a success from the start, is the manufacture of peat into "filler" for artificial

fertilizers. While this use has been condemned by the agricultural chemists, as likely to be misleading, in that it makes the finished fertilizer seem higher in Nitrogen than it should, as it contains some Nitrogen which is not available for plants, it is mechanically really an ideal substance for the purpose, because it absorbs the water from the freshly made mixtures of the ingredients of the fertilizers and prevents caking and spoiling. How much of the water absorbed by the peat is sold as fertilizers, does not appear, but probably not so much, in proportion, as is sold in butter by the chief consumers of the fertilizer at from 25 to 35 cents per pound.

At any rate, the peat in the form of a dry powder, sold for this purpose, brings the highest price per ton of any peat product now on the market.

The purely academic and experimental uses to which peat has been put abroad, are, as yet, in too early a stage of development for more than passing mention here. In the opinion of the writer, they do not at present offer many opportunities in this country, which is so rich in better raw materials for the purposes to which peat has been put; but that one may easily misjudge in such matters is illustrated by the success of the peat paper mill already mentioned. That a good-sized factory should be established on a peat bed in Michigan, when thousands of tons of flax straw, apparently a vastly better material for paper-making, are annually burned to get rid of them in neighboring states, is certainly an anomaly.

It may be then, that artificial wood and paving blocks will yet be made here in quantities from peat, and this opportunity for peat utilization should not be overlooked as a possibility of much promise.

From what has been said, it is evident that there is a basis for the belief that is in us, that our peat deposits are valuable, that they will in the near future be the basis for extensive developments and will give rise to profitable industries; but, it is also evident that the development can only come from careful and thoughtful study of the possibilities of the basal substance, and, until this is thoroughly done, no one of us can be certain of success in any of the fields which have been opened up before us here.

PEAT DEPOSITS AS GEOLOGICAL RECORDS.

CHARLES A. DAVIS.

In the United States, peat has been but spasmodically and rather superficially studied, until recently, and practically not at all to determine its value as a record of conditions which may have existed during the time in which it was in the process of formation. The great area of the country, and its richness in unexplored fields for research, each attractive and important in varying degree, have kept busy those who might have turned to the study of peat from its geological aspects; and but few botanists have considered it within their realm of research, except as a paradoxical substratum, in which plants, having nearly all the forms of protection against the loss of moisture from their tissues possessed by desert types, were yet growing where the soil was always apparently wet.

A few writers, in a casual way, have published sufficiently elaborate papers to show how little they really had worked below the surface, on the subject, and others have frankly copied these and thus perpetuated incomplete work and erroneous ideas.

In Canada, somewhat careful and extended work has been done on the so-called "fossil" peat beds, marking an interglacial period. European writers have gone much farther than any others and have published some important studies of peat deposits in various parts of the British Isles, Scandinavia and Germany, which have thrown light on some of the possibilities of this interesting type of recent fossil beds.

The basis for intelligent and profitable study of the geological history which is to be found in these deposits seems to lie in that fascinating field of botany which involves the relationships of plants to their environment, combined with the equally delightful study of physiography. In other words, before peat deposits, as such, can be profitably investigated, the way in which peat is now being formed must be thoroughly examined into, not alone from the viewpoint of the physiographer but as well from that of the plant ecologist. The deposits must be considered from the aspect of the origin and form of the surface on which they have been laid down, in order to know what to expect as to types of vegetation which may be found.

Previous to such a study, however, it is essential to become familiar with the conditions under which peat may be formed, and the habits and ecological relations of the important groups of plants which are concerned in peat formation, as well as the ways in which these may be modified by various physiographic and climatic conditions.

The following underlying principles must be kept in mind in making interpretations:

(1) Peat is always found where the ground water level is sufficiently high to prevent ordinary decay; this implies complete saturation of the material for the greater part of the time. The more complete the seclusion of air, the less the vegetable matter shows true decay.

(2) Plants of but few types, and of simplest structure, are able to live wholly submerged in water, and the number becomes rapidly less as the water becomes deeper, until it is rare to find any species which is permanently attached by roots to the soil, growing from a depth greater than 15 feet below the water surface, the maximum depth from which they start apparently depending upon the transparency of the water, although doubtless, other factors of growth must be taken into account. The floating Algae and the few seed plants which have no root attachments are not significant.

(3) Aquatic seed plants which have a part of their stems and leaves floating or emerged, grow in shallower water than the wholly submerged types, and become abundant in less than 10 feet of water, and, in the case of those with erect stems, rising much above the surface, 5 feet is about the maximum depth at which any are able to persist, while less than 2 feet limits the greater number of species. In water of less than this depth, a considerable number of species may give character to the vegetation.

(4) The turf, or mat-forming types, sedges and others, are limited lakeward by a depth of water somewhat more than one foot, and will persist for a time to about the same height above water level; as these plants build the deposit above the water level, and prepare the way for the woody plants, their relations are important.

(5) As soon as the surface of a peat deposit is above water, a great variety of marsh plants, capable of enduring a good deal of water about their roots, take possession of it and change the character of the material making up the peat. Most characteristic, and usually appearing first, are the shrubs, especially the bog heaths and certain willows. Closely follow.ng these types come the coniferous trees, and more often, Sphagnum.

(6) It is apparent that this series is only to be found complete in depressions permanently filled with water. It is also evident that where moisture conditions are favorable, a deposit may begin with any member of the series—thus on a wet, poorly-drained land surface, in a moist climate, the peat may be built up wholly from a single association of plants.

(7) There are evidently two general kinds of peat deposits recognizable from the physiographic form of the surface, the filled depression and the covered flat surface, or the "filled" bog and the "built-up" bog.

Whatever may be the order in which these items are taken up, it is apparent that two lines of investigation must be pursued rather thoroughly, if the full significance of the peat is to be understood.

Perhaps the most readily obtained information to be derived from this class of deposits, is that regarding climatic conditions and changes during the period in which the peat has been forming. In the north of Europe, notably in Denmark, and Scotland, examinations have been made which show that in the case of certain peat deposits, there have been cycles of milder climatic conditions, followed, and preceded by more severe ones, as certain beds of peat contain the remains of southern plant species which are associated above and below with those of more northern types. In our own country but little is known of the records to be found in the beds of Post-glacial peat, so numerous in the glaciated regions of the continent. In a few cases, the writer has found definite records of prolonged drought followed by wet periods, which must have been of considerable duration, but it is only under rather unusual conditions that it would be clear that a rise of water indicated by a complete change in the character of the plant remains, was due to increased rainfall, and not to interference with the drainage. It

is only in closed depressions of small extent that certain evidence may usually be found.

The evidence of climatic conditions, as expressed in inter-glacial peat deposits and soil beds, is, of course, well-known, and needs no elaboration here. Such beds are indications not only of the retreat of the ice for prolonged periods, but are definite records of their temperature and the humidity of the climate of the times. By much the same means that periods of drought and rainfall are indicated by the varying types of plant in the beds of a peat deposit, changes in drainage, due to various causes, are recorded. These changes may be due to the growth of the peat itself, and probably this is the more general cause, but the obstruction of outlets by drift material, by beavers, or in other ways, all produce the same effects.

It seems probable that, in many cases, such obstructions as result from the growth of the peat, may be correlated with drought periods, since in times of low water-level in the peat, such plants as the shrubs, trees and Sphagnum make rapid growth, cover new territory, and may invade the sides and even the bottom of the outlets, clogging them, or even obliterating them entirely, so that when normal rainfall appears again, the water does not find outlet at so low a level as formerly and a renewed stage of very wet conditions prevails for a longer or shorter time and is recorded by layers of plant remains showing the changes.

On the other hand, peat deposits of as great a thickness as 20 feet are known, which show, in a series of carefully taken samples, no marked variation in structure or in the type of plants building the peat; this may be interpreted as indicating conditions uniform with those of the present for the entire period.

Under certain conditions, the type of deposits under consideration may give records of movements of the crust of the earth, and, in some cases, form the most exact measure which can be obtained of the rate at which such movements are progressing.

A number of writers have called attention to deposits of peat at various stations along the Atlantic coast, which are now below the high tide level. During the summer of 1907, the writer had an opportunity to examine several such deposits at widely separated points along the coast; some of these were in salt marshes, while others, subjected regularly to tidal overflow, were covered by water that was nearly or quite fresh.

In the case of one salt marsh peat deposit, on the shore, near New Haven, Connecticut, the bottom of the deposit was a soil-bed with quantities of tree roots, stumps, etc., with a gravelly till below. The soil was nearly black, rich in humus, and was clearly similar to that usually found in tree-covered swamps of the present day, while the trees represented were swamp species of broad-leaved types. This layer was conspicuously darker than the peat above. Near the surface of the soil layer, shrub debris was abundant, and slightly above the root-crowns of the tree-stumps, these were replaced by an increasing quantity of the leaves and stems of sedges and other grass-like plants, above which for three or four feet such plants constituted the bulk of the deposit, forming a very characteristic, fibrous, brown peat, which was practically a turf, penetrated vertically by the roots of sedges and bulrushes. Above this the color and structure changed abruptly to gray, the peat became silty, and, instead of the sedge, the vegetable matter was practically all composed of the underground stems of the salt marsh grasses, now forming the covering of the marsh.

The story is plain, and scarcely needs interpretation, but it is certain

that at one time the bottom of the deposit was above the high water level, and was a tree-covered swamp. Subsidence began, and the water, still fresh, was for some reason held back in the swamp to a higher level than formerly, so that the trees were drowned. The soil became so wet that humification ceased, the trees died, were replaced for a time by shrubs and then, because of still higher water level in the soil, by the sedges and bulrushes. For a long time the upbuilding seems to have been about equal to the rise in water, which here was due to subsidence of the bottom, but finally the level of the surface became so low that the tide reached it, and from that time on, the silt-laden salt water has left a clear record. The total subsidence recorded is not far from 6 feet, and the rate of subsidence was equal to the rate at which upbuilding occurred. The subsidence is apparently still continuing at about the same rate, as if it were going on more rapidly, there would be an invasion of plants more tolerant of salt water; if less rapidly, the surface would be built up and the present plant society would give place to one less "halophytic" or salt-loving. If subsidence had stopped, the same indication would be present.

At various points in New Hampshire and Maine, similar fresh water peat beds were found in salt marshes. One study, made at Cutt's Island, Maine, was of especial interest, as it gave evidence of an elevation followed by subsidence. Below the present low water mark was found the characteristic deposit made by one of the salt marsh grasses which grows only above the half tide mark; this was capped by a turf identical in structure with the present surface deposit of the marsh, also below the present low water; superposed on this, was material which could have been formed only in a fresh water pond, above which in order came layers of sedges, shrub and moss, and then abruptly the peculiar mud, containing the underground stems of the salt thatch, appeared in the section, and at the top was the present turf. In another part of the same marsh, nearer the shore, the fresh-water material was considerably thicker, and the upper layers were abundantly filled by tree remains, both conifers and broad-leaved types being present. Evidently here the subsidence proceeded rather slowly, and the tide invaded the swamp gradually. This phase of the study of peat beds possesses so much interest, that one is tempted to prolong the discussion, but, after one more illustration, this time from North Carolina, it must be left.

Along the sounds of this state, especially those more remote from the sea and where the water is practically fresh, peat beds formed on a subsiding bottom are not uncommon. One such, near Elizabeth City, on Albemarle Sound, was more than 18 feet deep, and the structure of the peat was such that it is reasonably certain that the present conditions have continued throughout the time of its formation, that is, subsidence has been nearly uniform, with possibly slight halts, since it began. Halts in the subsidence would be indicated in such beds, by an accumulation of tree remains at definite depths. In a rather hasty examination of the deposit, no such tree bearing layers were found.

As to the rate of subsidence going on here, studies of the living plants growing on the deposit should show this: for example: one of the striking phenomena of these sounds to a stranger in the region, is the occurrence of living cypress trees growing in the water of the sounds, 100 yards, a quarter of a mile, or even longer distances from the shore; the question naturally arises, how did they get there and the obvious answer is Topsy's, "they jest growed." But even the least botanically inclined individual knows that no tree ever started from seed in several feet of water a quarter of a mile from

shore, where there are strong currents and high waves constantly stirring up the sandy bottom. The same objection would prevent the assumption that these trees were sprouts from drifting trunks or branches. It seems apparent, then, that at the time these trees were seedlings, they were growing on soil, it may be on isolated bars or on the mainland, above the low water level, and that subsidence to the extent of some feet has gone on during their life-time, the number of years and the amount of subsidence could be found out by examination of the trees themselves.

If it is assumed that plants have grown in the past in similar relations to their environment, as at the present time, which may safely be done, modern peat deposits at once become the key to the conditions under which all deposits of vegetable origin were formed in past geological times. Beginning with the Present, the whole series of peats, lignites, coals and even graphites may give not only records of the plant types which have existed, but also of the conditions under which they grew, and thus supply many of the details of climate, precipitation, water level and of other factors controlling organic life, which are now unknown, because the records have been imperfectly interpreted. For example: Peat deposits, associated with bars and beaches of the glacial and post-glacial lakes, which existed in the basin of the Great Lakes, if buried by materials which are certainly contemporaneous with the lakes, may give conclusive evidence of the depth of water over the surface on which the peat was formed, and, in this way, of the water level of the lake for that period.

From principles which have been stated already, it is apparent that peat which has been formed on a wet land-surface, or in very shallow water, differs materially in constituent plants, and hence in structure, and other essentials, from that built up in deeper water of ponds and lagoons; that which has been formed by wave-worn drift material, brought together by wind and wave-formed currents, in eddies, behind bars and in similar places, where the current was slackened, is also easily distinguished from other types, and, where found, is obviously a record of importance to one seeking information relating to the shore deposits of these ancient lakes, and to water levels while they were being formed, provided that he can read them.

Only recently, a specimen of peat was referred to the writer for examination from a peat bed connected with the shore deposits of Lake Chicago, and which had been taken by various observers to indicate a low-water stage in the lake. Examination showed, however, that it was made up of heterogeneous drift material which probably accumulated in water of considerable depth, and which certainly did not form above water-level, or in a marsh, as a turf stratum.

Coal and lignite often show remarkably diverse vegetable structure even in beds of the same horizon, or in different layers of the same bed; but, instead of considering this an anomaly, it is probable that, in the light which the study of the peat should give, it is to be expected under some conditions which favored the development of the vegetation from the remains of which, both coal, and lignite have been developed.

In like manner, it is evident from the intimate association of peat formed from fresh and salt water vegetation, mentioned above, that it is not necessary to assume, as sometimes has been done, that coal which has marine fossils above and below, or even interbedded with it, was formed from marine algae or from plants growing on salt or brackish marshes. Marine fossils and the usually greater amount of ash constituents in the coal which occurs with them, when found at the top of coal strata, may simply mark the time

when a subsiding coastal area of fresh marsh reached the level of the tides; when interbedded with the coal, it is more than possible that the deposit was formed upon an unstable coastal area which was oscillating up and down, or subject to occasional overflow caused by high tides, or severe storms, the thickness and character of the marine beds giving the evidence as to which factor should be given the greater weight. Marine beds below the coal may show nothing, except that there was an elevation of the surface before the coal began to be laid down.

To one who has examined the salt-marsh type of peat deposit, it is apparent that one of the most definite arguments which can be made against the hypothesis that coal could have been formed in marshes covered at regular intervals by the tides, is that the tidal waters are heavily silt-laden, and, wherever they appear, leave a heavy mineral deposit behind them. It is equally plain that an elevation or depression of a few inches, in an area near the tidal level will cause an entire change in the type of plants and in the resulting deposits.

It is scarcely necessary here, to call attention to the well-known and often-described power of preservation of the remains of animals and man, as well as those of plants, which peat possesses. The fact that this has been much more often noted in Europe than America is doubtless due to the more thorough development of industries based upon peat and its use as fuel, as well as the greater activity of geologists in working out the faunas of Pleistocene and Present times. A most excellent chance to increase the knowledge of the post-glacial faunas of Michigan is afforded by the present activity in draining marshes and ditching through peat deposits, and every large ditching operation should be watched, to save such vertebrate remains as may be uncovered. That such remains are of frequent occurrence, may be learned by talking with any intelligent ditcher, but it is only a rare occasion that any except the bones of the Mastodon are saved. Are we as geologists doing our duty in neglecting the opportunities thus offered.

A fascinating line of speculation may also be entered into as to the length of time which it may have taken a given thickness of peat, for example, measuring a period of coastal subsidence, to form. From this, it is but a step to conjecture as to the length of the time recorded in the accumulation of coal and lignite. Here, however, the knowledge obtained from the peat deposits is of the sort which puts the student in a very humble frame of mind, since he soon finds that practically each peat bed has its own rate of accumulation, depending upon so many factors that the problem is a most difficult one, if capable of solution at all.

It is apparently certain, however, other factors being the same, that peat develops more rapidly in a region of heavy rainfall, than in a more arid one, and, correlated with this, in a cool region than in a hot one, but the number of feet of peat which would develop in a given period, or the length of time in which one foot would be laid down, it is not possible to say with any definiteness, except for a given deposit after long-continued observation.

If these brief notes have served to call the attention of those present to a much neglected page of geological history, the aim of the writer is accomplished.

Ann Arbor, Michigan, April 3, 1908.

DIRECTIONS FOR DETERMINING THE OPSONIC INDEX OF THE BLOOD.

By E. C. L. Miller, M. D.

[From the Research Laboratories of Parke, Davis & Co., Detroit, Mich.]

The subject of immunity is being studied as never before. It is recognized to-day as the subject of paramount interest in medicine. Thanks to the genius of certain English workers, we are now able to make a quantitative determination of at least some of the factors which go to make up immunity. Heretofore, the only test for immunity consisted in inoculating the animal with the germ in question, and from the amount of culture which it could withstand we tried to form some idea of the degree of immunity. Now we are able to measure, *in vitro*, at least approximately, one factor in immunity —phagocytosis. The method is simple, and, fortunately, applicable to man as well as to the lower animals. This fact at once makes it of interest to the physician, for by this means he is brought one step closer to his patient's actual vital condition. Methods have also been discovered by which the degree of immunity toward any particular microorganism can be increased, and thus is placed in the practitioner's hands the means by which he can assist nature in resisting certain infections.

The opsonic index of a patient indicates the efficiency of his phagocytic defense against any particular microorganism as compared with the average normal person. Preliminary to making a determination of the opsonic index it is necessary to prepare (1) an emulsion of the bacteria in question, (2) a quantity of washed blood corpuscles, (3) a drop or two of the blood serum of the patient, and (4) a little normal pool serum. With these constituents in hand the actual test is made as follows:

Equal portions of the emulsion of bacteria, the washed blood corpuscles and the pool serum are mixed and incubated. During this incubation some of the bacteria are taken up by the phagocytes. Then smears of this mixture are stained and examined with the microscope in order to determine to what extent the bacteria have been taken up. The number of bacteria in the phagocytes is systematically noted as they come into view, and when 50 or 100 leucocytes have been thus counted the average is determined. This average is the phagocytic count when using the patient's serum.

An exactly similar test, carried through by using blood corpuscles, bacterial suspension and pool serum in equal quantities, gives the phagocytic count when using pool serum. The opsonic index is found by dividing the phagocytic count of the patient's serum by the phagocytic count of the pool serum.

An opsonic index much below normal usually indicates inadequate power of resistance on the part of the patient toward the bacterium in question, and this power can be increased by the administration of homologous bacterial vaccines; a bacterial vaccine in this sense being simply a suspension of the bacteria in physiological salt solution, sterilized properly and standardized. A bacterial vaccine may be made from a pure culture obtained from the patient himself (in which case it is spoken of as an autogenous

vaccine) or it may be made from corresponding bacteria obtained from similar cases (stock vaccines).

In gonorrhea, stock vaccines must be largely used, owing to the difficulty encountered in many cases in obtaining autogenous cultures. The same is true in tuberculosis, with the added factor that the germs must be prepared for absorption by rather elaborate processes; the best known of the resulting products being Tuberculin, T. R. and Tuberculin B. E.

In the other infections, autogenous vaccines can be readily made by those

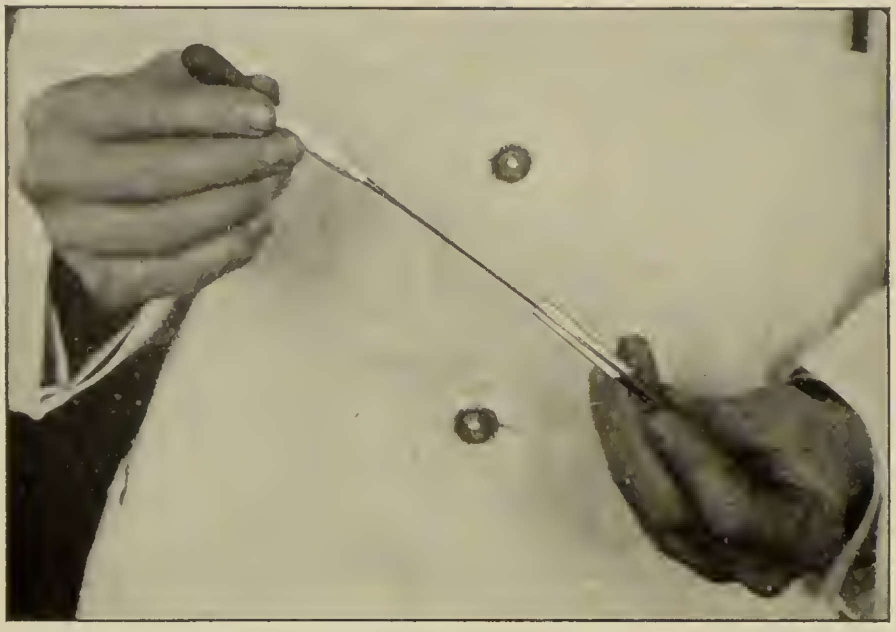


Fig. 1.—Emulsifying bacteria.

having laboratory facilities and training, or stock vaccines may be used. Whether autogenous vaccines are markedly superior to stock vaccines has not yet been determined.

The various steps in determining the opsonic index and making bacterial vaccines will now be taken up in detail.

Preparing the Emulsion of Bacteria.—The culture of the germ in question growing on inclined agar is removed and emulsified, the method of emulsifying depending upon the character of the germs, and upon the age of the culture. In a young culture (12 to 24 hours) it is usually sufficient to wash off the culture with 0.85 per cent salt solution and draw it up and down repeatedly in a pipette (see Fig. 1). In the case of bacillus tuberculosis the emulsion may be made from fresh culture, or from dry, dead tubercle germs. These need considerable grinding to properly emulsify them. After emulsifying and diluting, the suspension is centrifugalized to remove the clumps of bacteria (see Fig. 2) and then tested for density by determining its phagocytic index when opsonized with normal serum. The proper consistency is one that will give a count of about two bacteria per leucocyte for tubercle, and a count of from three to five for other germs. The best

Fig. 2.—Tube of bacterial suspension ready to centrifugalize, with a companion tube equally filled with water to balance the centrifuge.

strength of saline solution for diluting tubercle and gonococcus is 1½ percent; the strength to use for most other germs is 0.85 per cent.

FIG. 3.—Special blood pipette.

Preparing the Washed Blood-corpuscles.—Things required: an ordinary gauze bandage or a piece of light rubber tubing; 1½ per cent* sodium citrate solution; a special blood pipette (see Fig. 3); two blood capsules (see Fig. 4). The capsules may be of various sizes and shapes, depending on the amount of corpuscles required, and upon the character of the centrifuge to be used. Fill two capsules three-quarters full of the sodium citrate solution; make a pricking needle by drawing out the long capillary arm of the pipette in a pilot flame (see Figs. 5 and 6), wind the thumb centrifugally with the bandage or rubber tube in order to cause marked congestion in the tip. Prick the thumb with the glass needle (see Fig. 6)—preferably at the root of the nail—and allow the blood to flow into one or both of the capsules containing sodium citrate solution (see Fig. 7). Mix the blood and citrate solution, and, having balanced the tubes carefully, centrifugalize until the corpuscles are thrown down (see Fig. 4). Remove the supernatant sodium citrate solution carefully with a pipette, and wash the corpuscles in 0.85 per cent sodium chloride solution. Again centrifugalize and remove the saline as completely as possible. The last drop of saline can be best removed by inclining the tube and drawing the saline into a capillary pipette from the back portion of the meniscus (see Fig. 8).

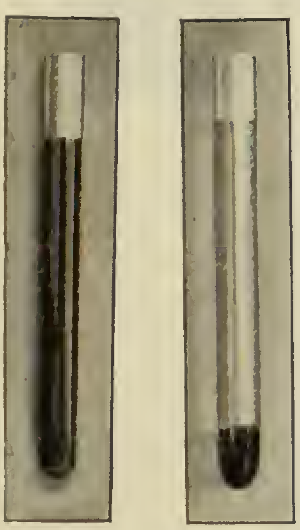


FIG. 4.—Blood tubes before and after centrifugalizing.

During the time that the blood is flowing into the capsule it can be conveniently mixed with the citrate solution by occasionally raising the closed end of the capsule while the open end is kept well pressed against the thumb. The bubble of air passing from end to end of the tube thoroughly mixes the fluids. Similarly the corpuscles can be washed in the sodium citrate solution by closing the mouth of the tube and alternately inverting it. The air bubble will gently but efficiently wash the corpuscles. Vigorous shaking of the blood-corpuscles is to be avoided.

Preparing the Serum.—Bleed the finger, as before, allowing the blood to flow into the special blood pipette (see Fig. 9). Seal the needle end of the blood pipette (see Fig. 10), and when cool shake the blood down into this end (see Fig. 11). Place in the incubator for fifteen to thirty minutes, and, if the serum be not clearly separated by the end of this time, centrifugalize it (see Fig. 12). It frequently happens that the surface of the blood clot dries and adheres to the inner surface of the glass tube so firmly that it cannot be thrown down in the centrifuge. In such case break off the curved end

*A solution containing 8.5 grm. sodium chloride and 5 grm. sodium citrate per liter also gives good results.

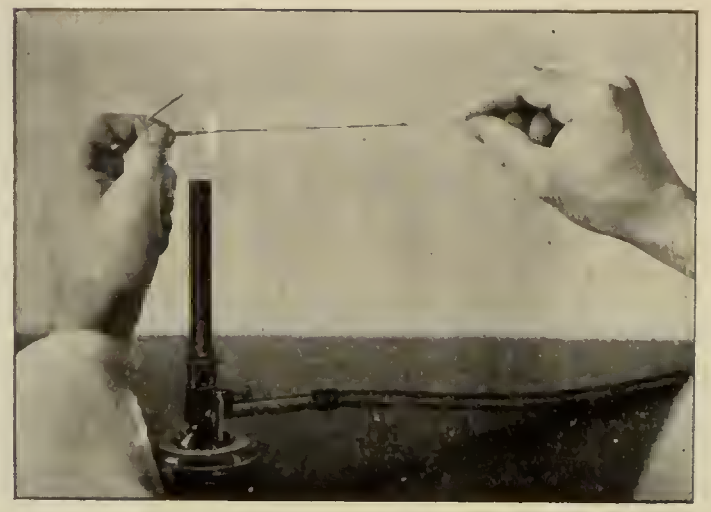


Fig. 5.—Drawing out long end of blood pipette to form pricking needle.

of the blood pipette and loosen the blood from the glass with a platinum wire. If the blood is to be transported some distance seal off the curved end of the blood pipette after the blood has been shaken down into the straight end. In sealing either end of the pipette it is well to so grasp the rest of the pipette that the portion containing blood is completely covered by the fingers, in order to protect the blood against undue heat. In obtaining blood for this work it is better not to squeeze or knead the finger.

Fig. 6.—Blood pipette ready for use, with short arm broken off and pricking needle at other end.

The glass pricking needle is thoroughly aseptic, causes very little pain, and gives a free flow of blood. It is best made in the small pilot flame, provided with some Bunsen burners to keep the gas alight when the main flame is turned off. Hold the capillary tube in this flame until it softens, then remove from the flame and rapidly draw the softened part out into a hair (see Fig. 5). Break off the flexible portion, and the sharp point remaining is the pricking needle (see Fig. 6).

Beginners who are not accustomed to making blood examinations sometimes have difficulty in obtaining an adequate flow of blood. If the following points are observed, one puncture will usually supply blood enough for both the serum and the corpuscles.

The glass needle should not be too fine: The rubber tube should be so wound (from the base to the tip) as to produce good compression in the finger.

Make one good puncture, not several half-hearted attempts.

Have the citrate solution and the blood pipette ready so that the blood will not be lost.

As soon as the puncture is made break off the needle end by pressing it against any hard object, as it is liable to be plugged, in which case the blood will not flow into the capsule.

Putting Up the Test.—Take up in an opsonizing pipette equal quantities of blood-corpuscles, bacterial emulsion, and blood serum in the order named, separating them by means of air bubbles (see Fig. 13). Drive the liquids

FIG. 7.—Collecting blood-corpuscles.

out on to a slide and mix thoroughly (see Fig. 14). Take up the pipette, seal the end in the flame (see Fig. 15), and incubate for fifteen minutes. In drawing the mixture into the pipette for the final time, care should be taken to avoid air bubbles, as these interfere with phagocytosis (see Fig. 17).

A convenient form of centrifuge for opsonic work.

In order to get accurately measured portions of the different fluids, the usual method is to make a mark with a wax pencil on the capillary portion of the opsonizing pipette, about $\frac{5}{8}$ or $\frac{3}{4}$ of an inch from the end. Then, by means of a rubber nipple on the other end, the blood corpuscles are drawn

FIG. 8.—Removing last drops of saline solution.

into the capillary tube up to the mark. The pipette is then removed from the corpuscles, and the column of the corpuscles lying between the end and the mark is drawn up the tube a short distance, leaving an empty space at the end of the capillary tube. The suspension of bacteria is now drawn in up to the mark and remains separated from the blood-corpuscles by the distance the corpuscles were withdrawn from the end. In a similar way a por-

FIG. 9.—Collecting blood for serum.

tion of the blood serum is drawn in, and then all are driven out and mixed.

Beginners sometimes have difficulty in working accurately with an opsonizing pipette, but a little practice usually brings confidence and accuracy. Pushing the glass tube well up into the rubber nipple and grasping the glass tube through the rubber gives one a firmer grasp and a more delicate control over the column of liquid. Drawing the corpuscles in first helps, as they do not move as freely as the thinner liquids. Those who prefer can manipulate the pipette by mechanical means, using either the simple rubber tube and screw clamp as shown in Fig. 16 or the more elaborate pipette holder shown

FIG. 10.—Sealing needle end of blood pipette.

in Figs. 17 and 18. To avoid air bubbles when drawing the mixture into the pipette for the last time, have the end of the capillary tube square-cut, hold the pipette perpendicular to the slide, and draw in slowly (see Fig. 19).

Making the Smear.—Remove the opsonizing pipette from the incubator; break off the sealed tip; drive the contents on to a slide; mix, as shown in Fig. 14, then place a small drop on one end of a slide (see Fig. 22) and spread out into a film by means of a special spreader. The spreading is usually done by means of another slide, from which the corners have been broken

FIG. 11.—Blood shaken down into sealed end of blood pipette.

FIG. 12.—Blood pipette after centrifugalization, showing serum separated. The upper end must afterwards be broken off to give access to the serum.

off, in order that the smear may not cover the entire width of the slide (see Fig. 20). A good smear greatly facilitates the otherwise laborious work of counting, and each worker usually develops his own favorite way of accomplishing this result. Perhaps as good a form of spreader as any is one with the spreading edges sharp and smooth and the spreading end concave (about $1\frac{1}{2}$ diopters). It is conveniently made by nicking the edge of a slide with

Fig. 13.—Opsonizing pipette containing blood-corpuscles, bacterial emulsion, and blood serum.

a triangular file and breaking it across. This broken end has very sharp edges, and, with a few trials, one with the proper curvature is usually obtained. Then break off the corners and the spreader is complete. In using such a spreader, it should be drawn very lightly or it will be soon spoiled by having the corners worn off. Such a spreader is brought in contact with the drop to be spread, moved slightly to distribute the drop uniformly across the end of the spreader, and then, while held at an angle of about 20 degrees above the horizontal, is drawn along the slide until the drop is exhausted (see Fig. 21.) The drop should not be so large as to extend to the end of the slide (see Fig. 22). A good smear should be uniform in consistency, and most of the leucocytes should be found along the edges and at the end. For convenience in counting it is well to have the smear terminate abruptly, and not be drawn out into threads or irregular forms (see Fig. 23).

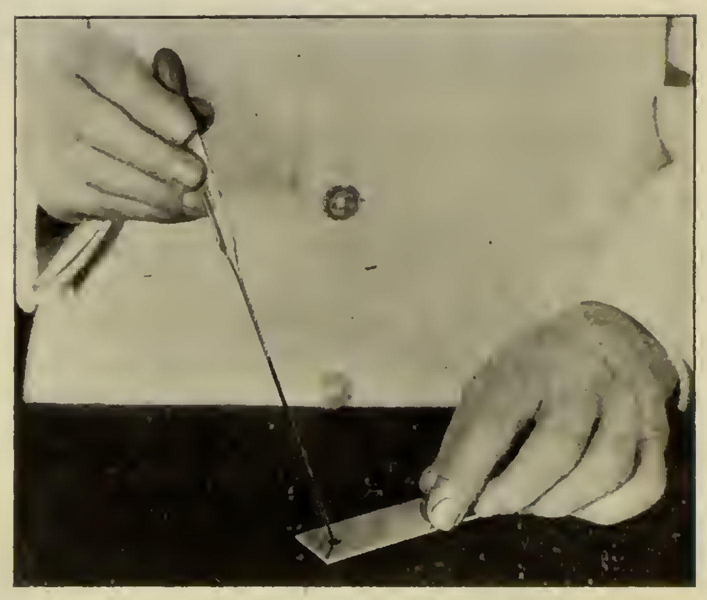


Fig. 14.—Mixing the fluids by repeatedly drawing them into the pipette and expelling them on to the slide.

Staining.—Any good stain that brings out in sharp relief the bacteria and white blood-corpuscles can be used. For tubercle, carbol-fuchsin with methylene blue as a counter-stain is usually employed. For staphylococcus and other germs, Hastings' or J. H. Wright's stain may be used.*

Two rods of brass or of glass, about 2½ inches apart, supported over a sink, make a convenient rack for staining tubercle (see Fig. 24). The slides are placed across these rods, and the fixing, staining, washing, etc., done

* Directions for preparing these stains may be found in the *Journal of Experimental Medicine*, 1905, Vol. 7, page 265 (Hastings), and the *Journal of Medical Research*, 1902, Vol. 7, page 138 (Wright).

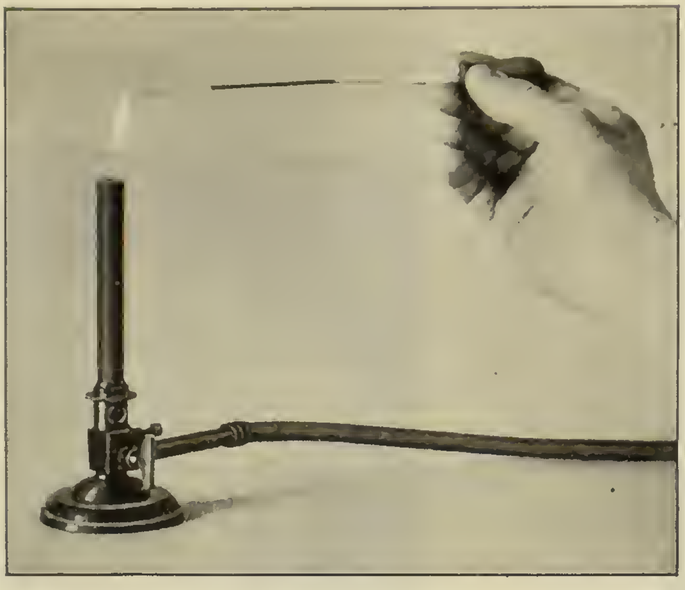
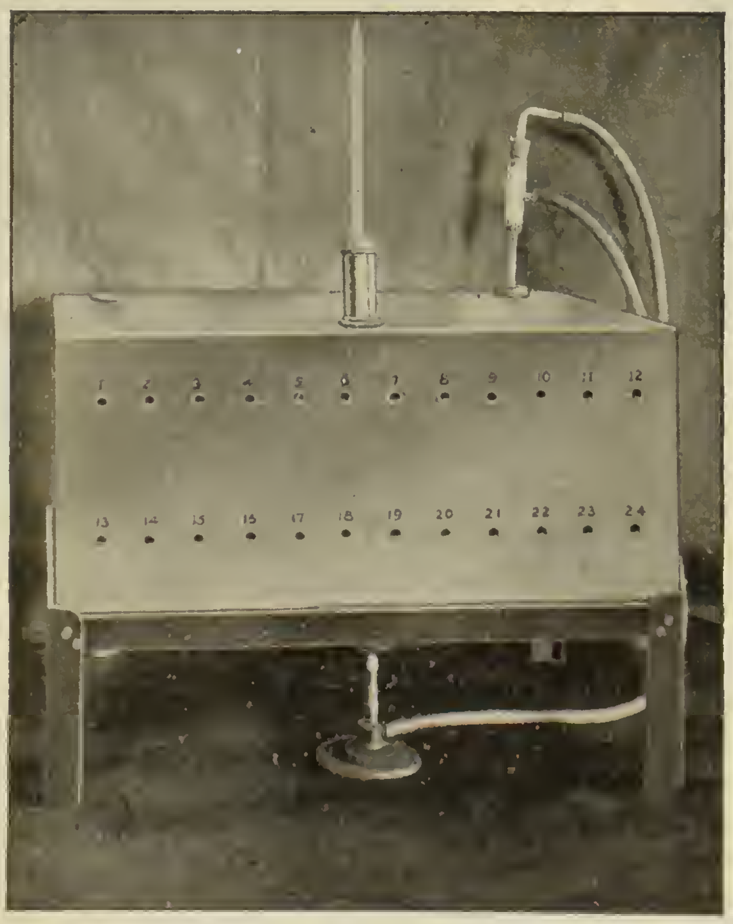


FIG. 15.—Sealing end of opsonising pipette in flame.

to all at one time. A piece of filter-paper cut to proper size and laid on the slides serves the double purpose of filtering the stain and of distributing it uniformly over the slides.

Method of Staining Tubercle.—1. Fix the slides in saturated solution of corrosive sublimate. Wash.



A small incubator of special design for opsonic work.

2. Stain with carbol-fuchsin about one minute (carbolic acid 5, fuchsin 1, water 100). The slides should be heated, while staining, until steam is given off. Wash.

FIG. 16.—Mechanical control for opsonizing and other pipettes devised by Dr. W. H. Hutchings.

FIG. 17.—Special pipette holder for opsonic or other small-calibered pipettes. The long handle gives a firm pistol-grip on the pipette while the screw enables one to control the column of liquid very accurately. The glass pipette can be introduced into the soft rubber stopper as readily and quickly as into a rubber nipple.

3. Decolorize in $2\frac{1}{2}$ per cent sulphuric acid. Wash.

4. Treat for a few seconds with 5 per cent acetic acid to reduce the prominence of the red blood cells. Wash.

5. Counter-stain with alkaline methylene blue (methylene blue 1, sodium carbonate 1, water 200). Wash lightly and dry.

Method of Using Hastings' or Wright's Stain.—Without any preliminary fixing, cover the film with the stain and allow to stand forty-five seconds. Add, carefully, drop by drop, about an equal volume of distilled water, mix, and let it stain for two minutes. Wash with distilled water and dry.

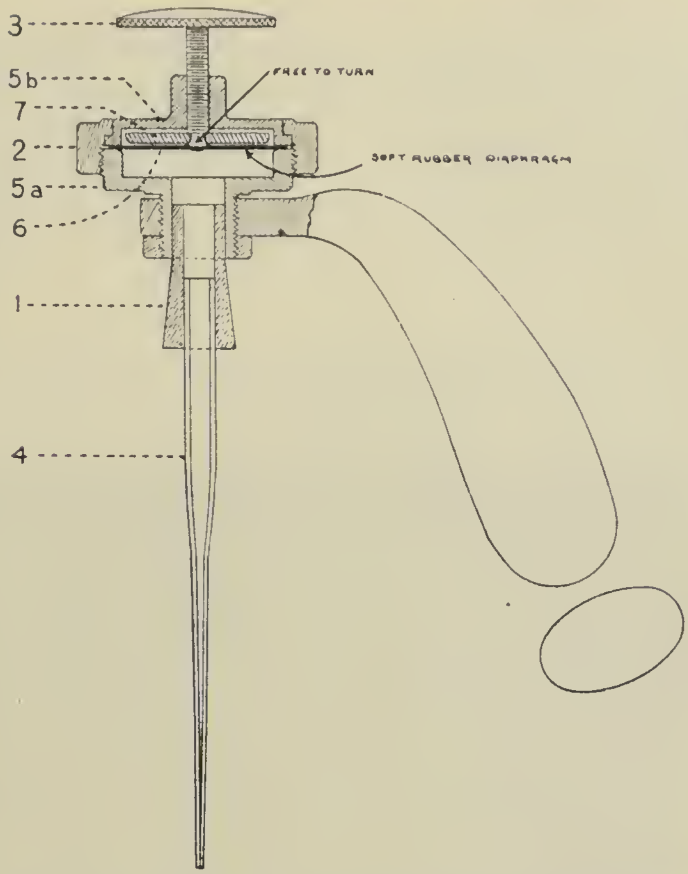


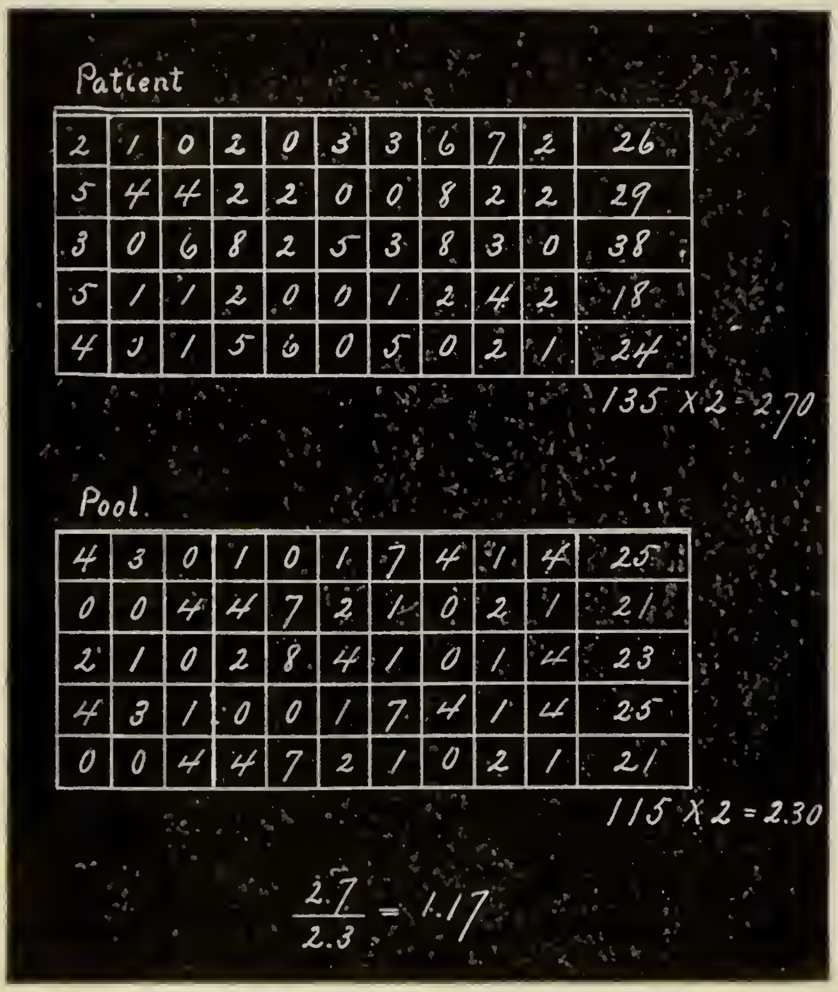
FIG. 18.—Section of pipette holder shown in Fig. 17.

1. Rubber stopper by means of which air tight connections are made between the glass pipette (4) and the body of the holder (5a).
2. Union by which the two parts of the pipette (5a and 5b) are held together with the rubber diaphragm (6) firmly clamped between them.
3. Screw control: By turning this screw to the right the disc (7) is lowered and the rubber diaphragm (6) made tense. Then a slight turn of the screw (3) to the left will draw liquids into the pipette, and a corresponding turn to the right will expel them.

FIG. 19.—Taking up mixture without air bubbles.

Counting.—The essential in counting is to set for one's self definite standards, and always adhere to them. Only typical polymorpho-nuclear neutrophiles should be counted. It is also well to use the same portion of the smear for counting, both for the patient's blood and for the control, as there is liable to be some difference in the count between those leucocytes found along the edges and those found at the end of the smear. It is also well to have some disinterested party occasionally mark the slides in cipher so as to eliminate any psychical error in counting.

FIG. 20.—Spreader.



Patient

2	1	0	2	0	3	3	6	7	2	26
5	4	4	2	2	0	0	8	2	2	29
3	0	6	8	2	5	3	8	3	0	38
5	1	1	2	0	0	1	2	4	2	18
4	0	1	5	6	0	5	0	2	1	24

135 X 2 = 2.70

Pool.

4	3	0	1	0	1	7	4	1	4	25
0	0	4	4	7	2	1	0	2	1	21
2	1	0	2	8	4	1	0	1	4	23
4	3	1	0	0	1	7	4	1	4	25
0	0	4	4	7	2	1	0	2	1	21

115 X 2 = 2.30

$$\frac{2.7}{2.3} = 1.17$$

TABLE I.—Counting for the Opsonic Index.

Chart showing the number of bacteria counted in a series of leucocytes and the method of finding the phagocytic count and the opsonic index.

The number of bacteria (135) found in fifty leucocytes is multiplied by two to give the number in 100, then pointing off two places, gives the average per leucocyte (2.7); the phagocytic count of the patient divided by the phagocytic count of the pool gives the opsonic index (1.17).

FIG. 21.—Making the smear.

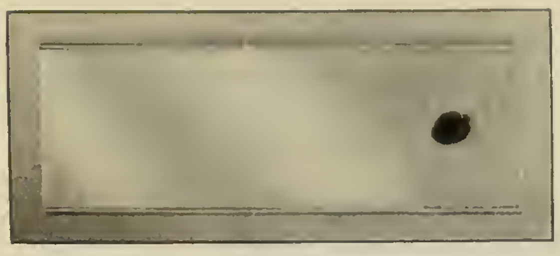


FIG. 22.—The drop ready to spread.

FIG. 23.—The smear.

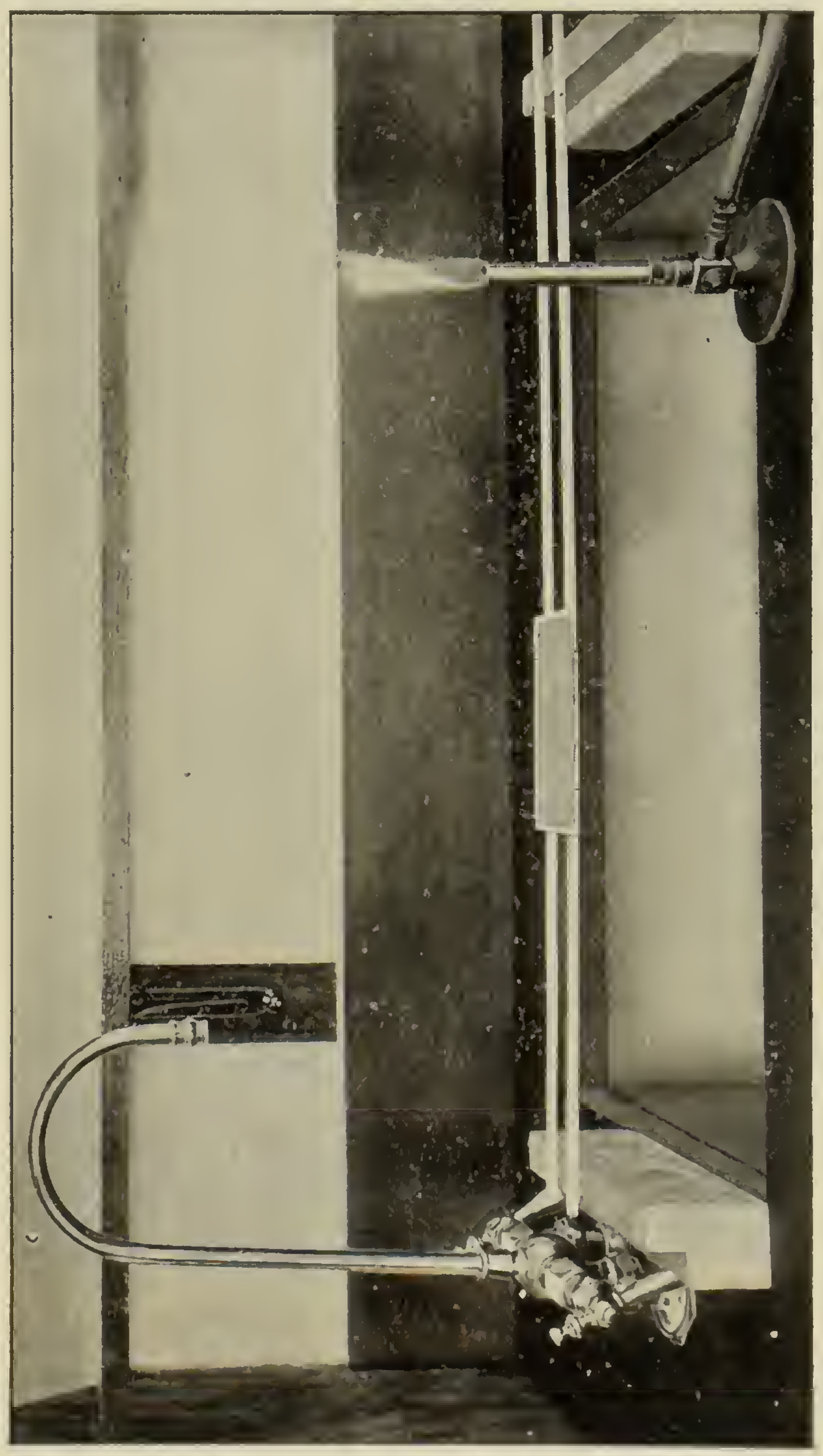


FIG. 24.—Staining rack.

The average number of bacteria found in the phagocytes gives the phagocytic count. The phagocytic count of the blood to be tested, divided by the phagocytic count of the pool serum, gives the opsonic index (see Table I).

Preparation of Bacterial Vaccines.—A pure culture of the bacteria from which the vaccine is to be made is grown on inclined agar for twenty-four hours. From 2 to 4 cc. of sterile physiological salt solution is placed in the culture tube, and the growth separated from the agar by means of a platinum wire.

Red Cells	Bacteria
16	12
14	8
9	5
17	15
16	10
20	9
11	10
19	13
15	9
6	5
17	14
8	6
18	11
18	17
22	10
18	8
14	16
14	10
18	16
18	20
308	224

$$308 : 224 :: 5000 :$$
$$X = 3636$$
$$\frac{3636}{400} = 9$$

TABLE II.—Counting the vaccine.

This chart shows the count of bacteria and of red blood cells in twenty successive fields of the microscope and the subsequent computations.

The number of red cells counted (308) is to the number of bacteria counted (224) as the number of red cells per cubic centimeter in normal blood (5,000,000,000) is to the number of bacteria per cc. in the suspension (3,636,000,000). This count (3,636,000,000) divided by the count desired in the final dilution (400,000,000) gives the number of times (9) this suspension must be diluted to bring it to the desired strength.

The salt solution containing the separated germs is transferred to an empty sterile test-tube and the neck of the tube sealed in the flame (see Fig. 25). When cool the tube is vigorously shaken, so as to thoroughly emulsify the bacteria and disintegrate any clumps that may have formed. After shaking, the tube is opened and a small portion (about one drop) taken out and reserved for the count. The tube is again sealed and placed in the water-bath, at 60° C., for such time as is required to kill all the bacteria contained in it—usually one-half hour is sufficient.

The enumeration of the bacteria in the portion reserved for the count is done as follows: By means of an opsonizing pipette and nipple, take up one part of freshly drawn normal blood, one part of the vaccine, and two or three parts of physiological salt solution. These are blown out on to a slide and mixed in the usual way, and than a portion is spread out into a film. This film should be made very thin and uniform, the same as a film for a differen-

Fig. 25.—The tube of bacterial suspension sealed ready to shake.

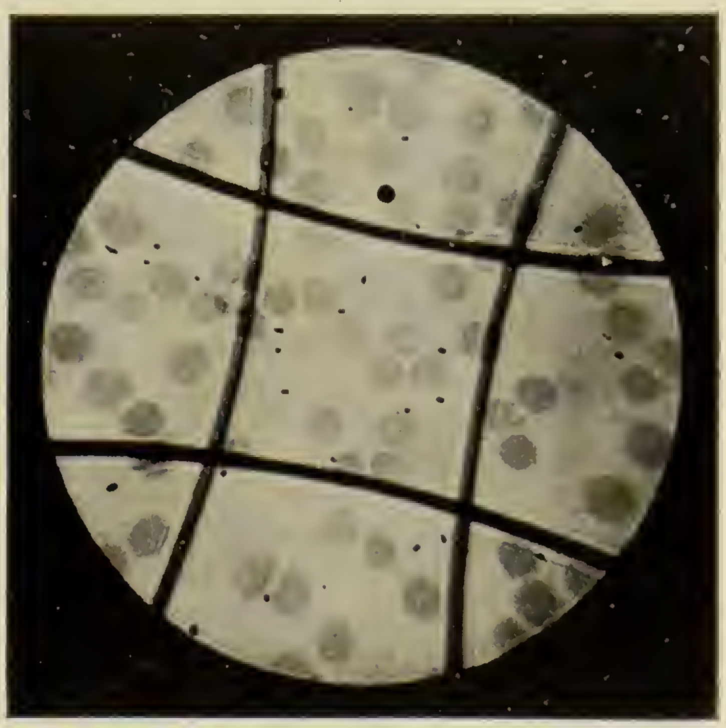


Fig. 26.—Photomicrograph showing cross-hairs, bacteria and red blood corpuscles.

tial leucocyte count, and not like the smear described above for a phagocytic count. The film is stained, and the number of bacteria and of red corpuscles in successive fields of the microscope are counted until at least 200 corpuscles have been counted. As the number of red blood-corpuscles per cubic centimeter is five thousand million, the number of bacteria per cubic centimeter can be determined from the results of the counting by a simple arithmetical proportion (see Table II). If the bacterial vaccine is very dense, it is well to take one part of vaccine and a sufficient number of parts of normal blood, so that the number of bacteria does not differ greatly from the number of red blood-corpuscles. The vaccine can now be standardized by dilution to any required strength. The count of the concentrated vaccine divided by the count required in the dilute form will give the number of times it should be diluted (see Table II). The vaccine should be sterilized

and preserved in sealed glass tubes. It is well to add 0.2 per cent of lysol or some other preservative to guard against contamination when opened. In counting it is convenient to have the field of the microscope divided by cross hairs, as shown in Fig. 26. This can be readily accomplished by placing hairs on the diaphragm of the eyepiece, as shown in Fig. 27. Select a good, straight, black hair, cut off four pieces of suitable length. Spread a little cedar oil on the diaphragm, and by means of tweezers place the hairs in position, spacing them so that the central square is about one-third of the diameter of the opening. Replace the eye-piece in the microscope, and if the hairs are not visible and sharp, the diaphragm must be moved until they are in focus.

Dosage.—In administering bacterial vaccines for therapeutic purposes, the frequency of administration and the size of the doses depend on the kind of vaccine used and on the patient. As a general rule, that dose should be given which gives the maximum of positive phase consistent with the minimum of negative phase (see Fig. 28). In round numbers, the doses frequently used for the various bacteria are as follows: Staphylococcus 300,000,000, pneumococcus and streptococcus 50,000,000, gonococcus 10,000,000, tubercle (T. R.) 1-3000 mg. to 1-800 mg. It is always best to begin with a small dose and work up, as some patients can stand two or three times as much as others.

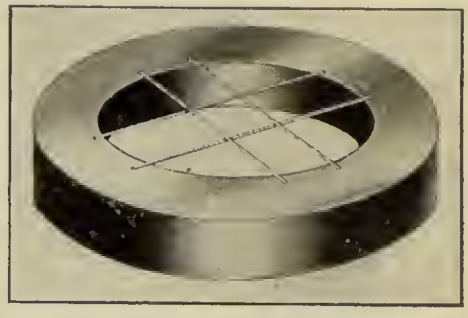


Fig. 27.—Diaphragm of eyepiece showing hairs in position.

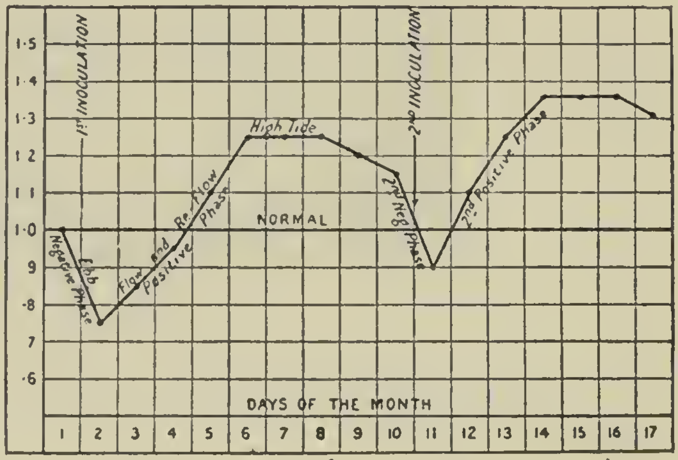


Fig. 28.—Opsonic curve showing constituent parts (after Ross.)

The Pool.—The opsonic index of a serum expresses the ratio which its phagocytic index bears to the phagocytic index of "normal serum." Normal serum in this sense would be serum that had never been influenced by the particular bacterium in question. Owing, however, to the limitations of our knowledge, this is quite an impractical standard, and hence resort is had to pooling the blood serum of several presumably normal persons. Each person is bled in the usual way, and after the serum separates equal portions of the sera are taken and mixed. This mixed serum is the pool. If great accuracy is desired, each constituent serum should be tested against the

pool, and those varying markedly from the pool eliminated. A new pool should then be made from the others.

Cautions.—Samples of the blood designed for the opsonic test should be used as early as possible—they lose their opsonic power markedly after two or three days. The washed blood-corpuscles should be made up fresh. The bacterial emulsions should be made up fresh each time required, but an emulsion of tubercle may be kept in stock and used as needed. Each bacterial emulsion must be standardized by being opsonized with normal serum. Optical tests for the density of an emulsion are of value in that they enable one to dilute an emulsion to approximately the correct amount, but should not be relied on to take the place of the normal phagocytosis. The centrifuge used in preparing the blood-corpuscles should run without vibration, otherwise the leucocytes are liable to be disintegrated.

BIBLIOGRAPHY.

(To Jan. 1st, 1908.)

Aaron, Chas. D.: "A Clinician's Observations of Opsonic Therapy," *New York Med. Jour.*, Dec. 1, 1906, vol. 84, p. 1069.

Albert, H.: "The Opsonic Index and Vaccine Therapy," *West. M. Rev.* (Omaha), 1907, xii, 332-335. *Iowa M. J.*, 1907, xiv, 68-75.

Allen, Albert H.: "Homologous Bacteria as a Vaccine in Tuberculosis," *Jour. Amer. Med. Asso.*, July 20, 1907, vol. 49, p. 202.

Allen, R. W.: "Muscle Plasma: its Opsonic Power and Function in Phagocytosis," *Brit. Med. Jour.*, Aug. 25, 1906, vol. 2, p. 427.

Amberg, Samuel: "The Opsonic Content of the Blood of Infants," *Jour. Amer. Med. Asso.*, Jan. 26, 1907, vol. 48, p. 304.

Arkman, J.: "An Aspect of Vaccines and Antitoxins," *Lancet* (Lond.), 1907, ii.

Aspelin, E.: [Remarks on the So-called Opsonins in the Serum], *Allm. Sven. Lakartidn*, (Stockholm), 1905, vol. 2, p. 385.

Axamit und Tsuda: "Versuche uber die Spezifitat der Opsonischen Wirkung des Normalserums," *Wiener klinische Wochenschrift*, Aug. 29, 1907, No. 35, p. 1045.

Bacher, St.: "Uber Beeinflussung der Phagocytose durch Normales Serum," *Zeitschrift fur Hygiene und Infektionskrankh.*, 1907, vol. 56, p. 33.

Balban, W.: "Die Opsonin-lehre in Theorie und Praxis," *Wien. med. Presse*, 1907, xliii, 1281-1289.

Baldwin and Kinghorn: "Studies on Immunity in Tuberculosis: the Properties of the Serum of Immunized Rabbits," *Med. News*, Sept. 30, 1905, vol. 87, p. 636.

Bandi, J.: "Contributo allo studio dell endotossina del bacillo di Loffler—Indice Opsonico dei seri antidifterici," *Centralblatt fur Bakt.*, Sept. 19, 1907, Part 1, Referate, vol. 40, Nos. 5 and 6, p. 169.

Bandi, J.: "Agressina del Bacillo difterico: specificita ed azione antiopsonica di essa," *Centralbl. fur Bakt.*, Sept. 19, 1907, Part 1, Referate, vol. 40, Nos. 5 and 6, p. 170.

Banks, A. G.: "The Variations in Scarlet Fever of the Opsonic Power of Streptococci," *Jour. of Path.*, Oct., 1907, vol. 12, No. 1, p. 113.

Barr, Bell and Douglas: "A Case of Infective Endocarditis Cured by the Inoculation of a Vaccine Prepared from Organisms Found in the Patient's Blood," *Lancet*, Feb. 23, 1907, vol. 1, p. 499.

Barratt, J. O. W.: "The Phagocytosis of Red Blood-Cells," *Proc. Roy. Soc.*, 1905, vol. 76, ser. B, 512, p. 524.

Barratt, J. O. W.: "Ueber Erythrocytale Opsonin, Verhandl. d. Deutschen Pathol. Gessellschaft, X Tagung in Stuttgart, 1906. Ref. in *Zentralblatt fur Allg. Path.*, etc., 1906, vol. 17, No. 21, p. 880.

Barratt, J. O. W.: "On Opsonins in Relation to Red Blood-cells," *Proc. Roy. Soc.*, 1907, ser. B, vol. 79, No. B 528, p. 1.

Barratt, J. O. W.: "Die Reaktions geschwindigkeit Zwischen Opsonin und der roten Blutzelle," *Zeitschr. f. Physikalische Chemie,* 1907, vol. 58.

Barratt, J. O. W.: "Die quantitative Bestimung der Erythrocytenopsonine," *Centralblatt, fur Bakt.*, Part 1, Originale, April 25, 1907, Bd. 43, H. 8, p. 838.

Bass, C. C.: "Opsonins, Opsonic Index and Vaccine Therapy: Notes on the Principle, Technique, and Application," *New Orleans M. and S. J.*, 1906-7, vol. 39, p. 894.

Beddard, A. P.: "The Opsonic Power of Blood," Guy's Hosp. Gaz. (London), 1905, vol. 19, p. 420; *West Lond. Med. Jour.*, 1906, vol. 11, p. 13.

Beebe, T. C.: "Practical Application of Opsonic Therapy," *Boston Med. and Surg. J.*, vol. clvii, No. 3, p. 37.

Beitzke, H.: "Uber eine neue Theorie in der Immunitatslehre," *Berl. klin. Woch.*, July 1, 1907, vol. 44, No. 26, p. 818.

Bergey, D. H., "Protective Inoculations Against Bacterial Diseases," Penn., M. J. (Athens), 1905-6, vol. 9, p. 201.

Bergey, D. H.: "Studies on Phagocytosis," *Univ. Penn. Med. Bull.*, Sept. 1906, vol. 19, No. 7, p. 177.

Bergey, D. H.: "Opsonins and Vaccines as Applied to Surgical Therapy," *Univ. Penna. Med. Bul.*, June, 1907, vol. 20, No. 4, p. 50.

Bergey, D. H.: "Nature of the Opsonins and the Limitations of Bacterial Inoculations in the Treatment of Infection," *Month. Cycl. Pract. Med.* (Phila.) 1907, xxi, 337-442.

Bienenfield, B.: "Das Verhalten der Leukozyten bei der Serumkrankheit," *Jahrb. f. Kinderh.* (Berl.), 1907, lxv.

Boellke, O.: "Die Wrightschen Opsonine bei akute Infektionskrankheiten," *Deut. med. Woch.*, Sept. 21, 1907, vol. 33, No. 37, p. 1487.

Bordet, J.: "Les Leucocytes et les Proprietes Actives du Serum chez les Vaccines." *Ann. de l'Inst. Past.*, Bd. 9, 1895, p. 462.

Bordet, J.: "Recherches sur la Phagocytose," *Ann. de l'Inst. Past.*, 1896, vol. 10, p. 104.

Bordet, J.: "Sur le Mode d'Action des Serums Preventifs," *Ann. l'Inst. Past.*, April, 1896, vol. 10, No. 4, p. 163.

Bordet, J.: "Contribution a l'Etude du Serum Antistreptococcique," *Ann. de l'Inst. Past.*, 1897, vol. 11, p. 177.

Bordet, J.: "Wat Kan Men Verwachten van de Tegenwoordige, Immunisernngmethoden in Verband met Nieuwere Onderzoekingen" Geneesk. Courant (Amsterdam), 1906, vol. 60, p. 170.

Bosanquet and French: "The Influence of Anti-Tuberculous Serum on the Opsonic Index," *Brit. Med. Jour.*, April 13, 1907, vol. 1, p. 862.

Bossan, E.: "Opsonines et Index Opsonique comme moyen de control de l'effet Produit par Certaines medications," *Gazette des Hospitaux,* Jan. 24, 1907, No. 10, p. 111.

Bradley, E. B.: "Opsonins," *Phys. and Surg.* (Detroit), Dec., 1906.

Bradshaw, T. R.: "A note on the Influence of Antitoxic Serum on the Tuberculo-opsonic Index," *The Lancet*, May 19, 1906, vol. 1, p. 1387.

Bradshaw and Glynn: "The Significance of the Opsonic Power of the Blood and the Value of Estimations of the Opsonic Index in the Diagnosis and Treatment of Tubercular and Other Infections," *Liverpool Med. Chirurg. Jour.*, July, 1906.

Breton et Petit: "Sur les Proprietes Cytasique ou Opsonisantes du Serum dans la Fievre Typhoide," C. R. Soc. de Biol., 25 Mai 1907, vol. 62, No. 18, p. 941.

Brooke, B.: "Note on the Opsonic Index," *Dublin Jour. Med. Sci.*, Sep., 1906.

Brown, O. H.: "The Opsonic Treatment of Bacterial Diseases; its History, Principles and Technique," *Med. Fortnightly* (St. Louis), 1907, vol. 31, p. 285; *St. Louis Med. Rev.*, 1907, vol. 15, p. 369.

Brown, O. H.: "The Value of the Opsonic Index in the Diagnosis and Treatment of Tuberculosis," *St. Louis Med. Jour.*, May 25, 1907, vol. 15, No. 21, p. 517.

Brown, T. W.: "Treatment of Tuberculosis and Tuberculin Inoculation," *Brit. Med. Jour.*, May 20, 1905, vol. 1, p. 1089.

Bullock, Wm.: "Inquiry into the Opsonic Content of the Blood Serum in Healthy Individuals and in Patients Affected by Lupus," Trans. Path. Soc. (London), 1905, vol. 56, p. 334.

Bullock, Wm.: "On the Nature and Action of the Opsonic Substances in the Blood Serum," *Lond. Hosp. Gaz.*, Feb. 1905, vol. 11.

Bullock, Wm.: "On the Variations of the Opsonic Power in Health and Diseases," *Lond. Hosp. Gaz.*, March 1905, vol. 11.

Bullock, Wm.: "The Principles Underlying the Treatment of Bacterial Diseases by the Inoculation of Corresponding Vaccines," *Practitioner*, Nov., 1905, vol. 75, p. 589.

Bullock, Wm.: "The Treatment of Tuberculosis by Tuberculin," *Lancet*, Dec. 2, 1905, vol. 2, p. 1603.

Bullock and Atkin.: "Experiments on the Nature of the Opsonic Action of the Blood Serum," *Proc. Roy. Soc.*, 1905, vol. 74, p. 380.

Bullock and Western: "The Specificity of the Opsonic Substances in the Blood Serum," *Proc. Roy. Soc.*, ser. B, vol. 77, p. 531.

Bunch, L.: "On Opsonins and Treatment by Bacterial Vaccines," *Lancet*, Jan. 19, 1907, vol. 1, p. 144.

Bunch, L.: "On Opsonins and Immunity," *Lancet*, March 23, 1907, vol. 1, p. 803.

Campbell, J. A.: "The Opsonic Index, with Special Reference to its Value in the Diagnosis and Treatment of Certain Diseases," *Glasgow M. J.*, 1907, lxviii, p. 122.

Campbell, R. D.: "Suggested Modification in the Opsonic Estimation of Tubercle," *Brit. Med. Jour.*, April 13, 1907, vol. 1, p. 866.

Castellani, A.: "The Opsonic Treatment of Some Diseases of the Tropics," *Archiv. f. Schiffsund Trop.-Hyg.*, 1907, No. 8.

Charteris, F. J.: "Record of Changes Observed in the Blood Count and in Opsonic Power of a Man Undergoing a Prolonged Fast," *Lancet* (Lond.), 1907, ii, 685-687.

Cheyne, Watson W.: "Professor A. E. Wright's Method of Treating Tuberculosis," *Lancet*, Jan. 13, 1906, vol. 1, p. 78.

Clark, C. P.: "The Opsonic Index in Typhoid Fever," *Jour. Amer. Med. Asso.*, Dec. 29, 1906, vol. 47, No. 26, p. 2159.

Clemens, J. R.: "Bacterial Inoculation as Guided by Wright's Opsonic

Index Curve, with Special Reference to the Use of Tuberculin," *St. Louis Med. Review*, Feb. 3, 1906.

Cler, Ettore: "Ueber einige Eigenschaften des antimilzbrandserums Sclavos," *Centralblatt fur Bakt.*, part 1, orig., vol. 40, p. 241.

Cole, R. I., "Vaccine Treatment of Infectious Diseases," *International Clinics*, June, 1907.

Cole and Meakins: "The Treatment of Gonorrheal Arthritis by Vaccines," *Johns Hopkins Hospital Bulletin*, June and July, 1907, vol. 18, p. 223.

Coleman, J. B.: "Notes on a Case of Unresolved Pneumonia Treated by the Inoculation of Pneumococcus Vaccine," *Lancet*, March 24, 1906, vol. 1, p. 831.

Cowie and Chapin: "On the Reactivation of Heated Normal Human Opsonic Serum with Fresh Diluted Serum," *Jour. Med. Research*, Oct., 1907, vol. 17, No. 1, p. 57.

Cowie and Chapin: "Experiments in Favor of the Amboceptor-Complement Structure of the Opsonins of Normal Human Serum for the Staphylococcus Albus," *Jour. Med. Research*, Oct., 1907, vol. 17, No. 1, p. 95.

Crace-Calvert, George A.: "Observations on the Opsonic Index of Tuberculous Patients Undergoing Sanatorium Treatment," *Brit. Med. Research*, July 7, 1906, p. 19.

Crace-Calvert, George A.: "On Opsonins and the Opsonic Index and Their Practical Value in the Treatment of Disease," *Lancet*, Feb. 2, 1907, vol. 1, p. 279.

Craw, J. A.: "On the Mechanism of Agglutination," *Jour. of Hygiene*, 1905, vol. 5, p. 113.

Da Costa, John C., Jr.: "The Opsonic Index in Diabetes Mellitus," *Amer. Jour. of Med. Sciences*, July, 1907, vol. 134, No. 1, p. 57.

Dean, George: "An Experimental Inquiry into the Nature of the Substance in Serum which Influences Phagocytosis," *Proc. Roy. Soc.*, 1905, series B, vol. 76, p. 506; 1907, series B, vol. 79, No. B 533, p. 399.

Dean, G.: "Phagocytosis and Bactericidal Action," *Med. Press and Circ.* (Lond.), 1907, lxxxiv, p. 190.

Denys, J.: "Compte-rendu des travaux executes sur le Streptocoque Pyogene," *Centralblatt fur Bakt.*, 1898, part 1, vol. 24, p. 685.

Denys, J.: "Resultats Obtenus par le Serum Antistreptococcique." Internat. Med. Congress (Moscow), 1897, Sec. 3, p. 82.

Denys and Leclef: "Sur le Mecanisme de l'Immunite chez le Lapin Vaccine contre le Streptocoque Pyogene," *La Cellule*, 1895, vol. 11, p. 178.

Dodds, H. B.: "The Opsonic Index in the Diagnosis of Tuberculosis," *Brit. Med. Jour.*, July 7, 1906, vol. 2, p. 22.

Dodds, H. B.: "A Modification of Leishman's Method of Estimating the Opsonic Index," *Brit. Med. Jour.*, Oct. 12, 1907, vol. 2, p. 948.

Douglas, S. R.: "Further Observations on the Role of Blood Fluids in connection with Phagocytosis," *Proc. Roy. Soc.*, Jan. 11, 1904, vol. 73, p. 128.

Douglas, S. R.: "On the Action Exerted upon the Tubercle Bacillus by Human Blood Fluids, and on the Elaboration of Protective Elements in the Human Organism in Response to Inoculations of a Tubercle Vaccine," *Proc. Roy. Soc.*, 1904, vol. 74, p. 159.

Dreyer, George: "Discussion on Immunity, *Brit. Med. Jour.*, Sept. 10, 1904, vol. 2, p. 564.

Dudgeon, L. S.: "The Micrococcus Neoformans; its Cultural Characters and Pathogenicity and the Results of the Estimation of the Opsonic and Agglutinative Properties of the Serum of Patients Suffering from Malignant

Disease on this Organism and on the Staphylococcus Albus," *Jour. of Hygiene*, 1907, vol. 7, p. 13.

Duncan, R. K.: "The New Microbe Inoculation," *Harpers' Monthly Mag.* (New York and London), 1907, vol. 115, p. 204.

Dunham, Theodore: "Tuberculins and on Tuberculo-opsonic Index," *Annals of Surgery*, Oct., 1907, vol. 46, No. 4, p. 597.

Dunhill, T. P.: "The Opsonic Index as a Guide in Therapeutic Inoculations, with Some Results of Treatment by Vaccines," *Intercolonial Med. Jour. of Australia* (Melbourne), Nov., 1906.

Eberts and Hill: "Bacterial Inoculation in the Treatment of Localized Infection," *Am. Jour. of the Med. Sciences*, July, 1907, vol. 134, No. 1, p. 35.

Editorial: "The Value of the Tuberculo-Opsonic Index in the Diagnosis and Treatment of Tuberculous Infections," *Lancet*, Jan. 27, 1906, vol. 1, p. 237.

Editorial: "Leucocytes and Opsonins in the Defense of the Body," *Jour. Amer. Med. Asso.*, May 12, 1906, vol. 46, p. 1444.

Editorial: "Method of Determining the Opsonic Index," *Jour. Amer. Med. Asso.*, June 9, 1906, vol. 46, No. 23, p. 1783.

Editorial: "Bacterial Vaccines as a Cancer Cure," *Brit. Med. Jour.*, July 14, 1906, vol. 2, p. 104.

Editorial: "The Serum ( ) Treatment of Cancer," *Brit. Med. Jour.*, July 28, 1906, vol. 2, p. 214.

Editorial: "Neoforman's Vaccine for Malignant Growths," *Lancet*, Aug. 25, 1906, vol. 2, p. 517.

Editorial: "The Opsonic Index in Acute Infectious Diseases," *Jour. Amer. Med. Asso.*, Oct. 26, 1907, vol. 49, No. 17, p. 1442.

Editorial: "Opsonins and the Treatment of Disease," *Brit. Med. Jour.*, Nov. 3, 1906, vol. 2, p. 1233.

Editorial: "Therapeutic Inoculation of Bacterial Vaccines," *Jour. Amer. Med. Asso.*, Nov. 3, 1906, vol. 47, No. 18, p. 1490.

Ellett, G. G.: "A Note on the Effect of Bodily Exertion on the Opsonic Index of Healthy Persons," *Brit. Med. Jour.*, July 21, 1906, vol. 2, p. 131.

Emanuel, J. G.: "Opsonins and Vaccine Inoculations," International Med. Annual, 1907, p. 54.

Emery, W. d'E.: "A Lecture on Opsonic Indices," *Brit. Med. Jour.*, March 2. 1907, vol. 1, p. 496.

Famulener, L. W.: "Newer Facts Concerning Phagocytosis; The Opsonins," *Cent. States Med. Monthly*, Indianapolis, Jan., 1907, vol. 10, p. 1.

Fitzgerald, M. P., Whitman, R. I., and Strangeways, T. S. P.: "An Inquiry Into the Value of the Opsonic Index," *Bull. Cam. Study Spec. Dis.* (Cambridge), 1907, i, 115-144.

Fraser, E. T., "Value of Tuberculo-Opsonic Index in Diagnosis," *Glasgow Med. Jour.*, March, 1907.

Frederick, E. V.: "Opsonins and Aggressins," *Canadian Practitioner and Review*, June, 1906.

French, H.: "Opsonins and Their Utility in Practical Medicine," *Brit. Med. Jour.*, Feb. 2, 1907, vol. 1, p. 256.

French, R. E.: "Opsonic Factors, their Estimation and Use in Therapeutics," *Practitioner*, London, July, 1906.

Fyshe, J. C.: "The Question of Opsonins," *Montreal Med. Jour.*, Oct., 1906.

Geets, V.: "Technique du Dosage des Opsonines," *Progres Med. Belge* (Brussels), 1907, vol. 9, p. 57.

Gildersleeve, N.: "Opsonins, Opsonic Technique, Phagocytosis and Bacterial Therapy," *Monthly Cyclopædia of Practical Med.*, 1907, vol. 10, p. 394.

Gildersleeve and Carpenter: "Bacterial Inoculations in Multiple Abscesses and Superficial Gangrene of Toes," *Archives of Pediatrics* (New York), Sept. 1907, xxiv, p. 689.

Gray, H. M. W.: "Vaccine Treatment in Surgery, *Lancet*, April 21, 1906, vol. 1, p. 1099.

Greig-Smith: "The Probable Identity of the Opsonins with the Normal Agglutinins," *Proc. Lin. Soc.*, (N. S. W.) Part 4, Nov., 1905.

Gruber and Futaki: "Seroaktivitat und Phagozytose," *Munch. Med. Woch.*, Feb. 6, 1906, vol. 53, No. 6, p. 249.

Gruber: "Ueber Infection und Resistenz beim Milzbrand," *Centralblatt fur Bakt.*, Sept. 15, 1906, part 1, ref. vol. 38, Beilage p. 11.

Haentjens: "Uber das Ausbleiben der Phagozytose bei Complementbindung," *Munch. med. Wochenschr.*, 19 March, 1907, vol. 54, No. 12, p. 560.

Hamilton, A.: "Opsonic Index and Vaccine Therapy of Pseudodiphtheritic Otitis," *Jour. Infect. Dis.* (Chicago), June 15, 1907, vol. 4, No. 3, p. 313.

Harris, A. B.: "On the Use and Misuse of Tuberculin," *Practitioner*, Jan., 1906.

Harrison, W. S.: "On a Modification of Wright's Method for Counting the Bacteria Contained in a Culture," *Jour. R. A. M. C.*, March, 1905.

Hektoen, L.: "Phagocytosis and Opsonins," Proceedings New York Path. Soc., N. S. 6, Feb., 1906, *Jour. Amer. Med. Asso.*, May 12, 1906, vol. 46, No. 19, p. 1407.

Hektoen, L.: "The Role of Phagocytosis in the Anthracidal Action of Dog Blood," *Jour. Infect. Diseases*, March 2, 1906, vol. 3, No. 1, p. 102.

Hektoen, L.: "Are Opsonins Distinct from Other Antibodies?" *Jour. Infect. Diseases*, May 18, 1906, vol. 3, p. 434.

Hektoen, L.: "Phagocytosis of Red Corpuscles," *Jour. of Infec. Diseases*, 1906, vol. 3, No. 5, p. 721.

Hektoen, L.: "Is Scarlet Fever a Streptococcus Disease?" *Jour. Amer. Med. Asso.*, April 6, 1907, vol. 48, p. 1158.

Hektoen, L.: "Isagglutination of Human Corpuscles with Respect to Demonstration of Opsonic Index and to Transfusion of Blood," *Jour. Amer. Med. Asso.*, May 25, 1907, vol. 48, No. 21, p. 1739.

Hektoen, L.: "The Opsonic Index in Certain Acute Infectious Disease," *Centralbl. f. Bakt.*, 20 Aug., 1907, 1 Abt., Originale, Bd. 44, Heft. 5, p. 456.

Hektoen and Ruediger: "Studies in Phagocytosis," *Jour. Infect. Diseases*, 1905, vol. 2, p. 128.

Hollister, J. C.: "Vaccine Therapy and Passive Hyperemia in Surgery," *Surgery, Gynecology and Obstetrics*, Dec., 1906, vol. 3, No. 6, p. 740.

Horton, J. M.: "Einfluss Verschiedener Konservierungstemperaturen auf die Opsonine," Trans. Path. Soc. (Chicago), 1905, vol. 6, p. 297.

Horton, J. M.: "The Anthracidal Substance in the Serum of White Rats," *Jour. Infect. Dis.*, March 2, 1906, vol. 3, No. 1, p. 110.

Horton and Hamilton: "Further Studies on Virulent Pseudodiphtheria Bacilli," *Jour. Infect. Dis.*, March 2, 1906, vol. 3, No. 1, p. 128.

Houghton, E. M.; "A Review of the Opsonins and Bacterial Vaccines," *Therapeutic Gaz.*, Jan., 1907, vol. 31, p. 24.

Houston and Rankin: "The Blood in Relation to Skin Diseases," *Brit. Med. Jour.*, Oct. 6, 1906, vol. 2, p. 854.

Huggard and Morland: "The Action of Yeast in Tuberculosis, and its Influence on the Opsonic Index," *Lancet*, June 3, 1905, vol. 1, p. 1493.

Hume, W. E.: "The Opsonic Value of the Blood Serum," *Univ. Durham Coll. Med. Gaz.* (Newcastle), 1905-6, vol. 6, p. 123.

Huston, T.: "Staphylococcus Vaccine in Dermatological Therapeutics," *Brit. Med. Jour.*, April 15, 1905, vol. 1, p. 854.

Huston and Rankin: "A note on the Opsonic Power of the Serum with Reference to the Meningococcus of Cerebrospinal Fever Occurring in the Belfast Epidemic," *Lancet*, May 4, 1907, vol. 1, p. 1213.

Hutchings, W. H.: "Use of Bacterial Vaccines in Surgery," *Jour. Mich. State Med. Soc.* (Detroit), July, 1907.

Hutchings, W. H.: "Discussion on Opsonins and Vaccine Therapy," *Jour. Amer. Med. Asso.*, Oct. 12, 1907, vol. 49, p. 1248.

Ipiniburn: "Las Opsoninas y la Fagocitosis," *Gac. Med. d. Norte* (Bilbao), 1906, vol. 7, p. 355.

Jacobs and Geets: "On the Treatment of Cancer by Therapeutic Inoculations of a Bacterial Vaccine," *Lancet*, April 7, 1906, vol. 1, p. 964.

Jacobs and Geets: "L'etat actuel des recherches opsoniques," *Progres Med. Belge*, Brux., 1907, ix, 137-140.

Jeans and Sellards: "The Tuberculo-Opsonic Index and Treatment by Tuberculin," *Johns Hopkins Hospital Bulletin*, June and July, 1907, vol. 18, p. 232.

Joest: "Uber Opsonine (bakteritrope Substanzen). Sammelreferat fur *Zeitschrift fur Infektionskrankheiten....der Haustiere*, 1907, 11, 4-5.

Jousset: "La Methode 'Opsonique' de Wright," *Bul. Medicale*, 1907.

Kammerer, H.: "Uber Opsonine and Phagozytose im allgemeinen," *Munch. medizinische Woch.*, Sept. 24, 1907, No. 39, p. 1916.

Keith, R. D.: "On the Relationship Between Haemolysis and the Phagocytosis of Red Blood Cells," *Proc. Roy. Soc.*, 1906, vol. 77, series B, p. 537.

Kellogg, W. R. M.: "The Value of the Tuberculo-opsonic Index in Diagnosis and Treatment of Strictly Localized Tuberculous Lesions," *Northwest, Medicine*, Seattle, Jan., 1907, vol. 5, No. 1, p. 20.

King, J. M.: "A Further Report on Opsonic Treatment," *South. Pract.* (Nashville), 1907, vol. 29, p. 177.

Kinghorn and Twichell: "The Technique of the Tuberculo-opsonic Test," *Amer. Jour. Med. Sci.*, Aug., 1906, vol. 132, p. 203.

Kitt, T.: "Intravenose Schutzimpfungen mit Thermisch Abgetoteten Bakterien," *Monatsh. f. prakt. Tierh.* (Stuttgart), 1905, vol. 16, p. 461.

Klien, H.: "The Opsonins in Typhoid Immunity," *Johns Hopkins Hospital Bulletin*, June and July, 1907, vol. 18, p. 245.

Knight, A. L.: "The Opsonins," *Lancet-Clinic* (Cincinnati), April 27, 1907.

Knorr, E. A.: "A Contribution to the Study of the Opsonins," *Jour. Amer. Med. Asso.*, April 13, 1907, vol. 48, p. 1255.

Kraus, R.: "Die Fortschritte der Immunitatsforshung," *Centralblatt f. Bakt.*, part 1, Referate, Sept. 15, 1906, vol. 38, Beilage, p. 1.

Krause: "Ueber Spezifisches Tuberculin," *Zeitschrift f. Tuberculosis*, 9. 1907.

Lannin, E. E. J.: "The Life and Works of Sir A. E. Wright, with Especial Reference to Opsonic Treatment and its Results Thus far," *Montreal M. J.*, 1907, vol. 36, p. 458.

Lawson, D.: "Observations on the Opsonic Index of Patients Undergoing Sanitorium Treatment," *Brit. Med. Jour.*, Dec. 16, 1905, vol. 2, p. 1617.

Lawson and Stewart: "A Study of Some Points in Relation to the Administration of Tuberculin (T. R.)" *Lancet*, Dec. 9, 1905, vol. 2, p. 1679.

Leary, T., and Medalia, L. S.: "Bacterial Opsonins and Vaccines," *Med. Comm. of Mass. Med. Society*, vol. xx, No. 3, p. 671-753.

Ledingham, J. C. G.: "The Inhibitory Action upon Subsequent Phagocytosis, Exerted on Active Normal Serum by Inactive Normal Serum through which Bacilli have been Passed," *Proc. Roy. Soc.*, Sept. 6, 1907, ser. B, vol. 79, No. B 534, p. 482.

Leishman, W. B.: "The Bactericidal Action of the Blood," *Brit. Med. Jour.*, March 23, 1901, vol. 1, p. 707.

Leishman, W. B.: "Note on a Method of Quantitatively Estimating the Phagocytic Power of the Leucocytes of the Blood," *Brit. Med. Jour.*, Jan. 11, 1902, vol. 1, p. 73.

Leishman, Harrison, Smallman, and Tulloch: "An Investigation upon the Blood Changes following Antityphoid Inoculation," *Journal of Hygiene*, 1905, vol. 5, p. 380.

Leishman, W. B.: "Some Experiments in Connection with Stimulins," *Trans. Path. Soc.* (London), 1905, vol. 56, p. 344.

Levaditi, C.: "Sur l'etat de la Cytase dans le Plasma des Animaux et des Organismes Vaccines contre le Vibrion Cholerique," *Ann. de l'Inst. Pasteur*, 1901, vol. 15, p. 894.

Levaditi, C.: "Les opsonines et le traitement des maladies infectieuses par la methode de Wright," *La Presse Medicale*, Sept. 7, 1907, No. 72, p. 569.

Levaditi et Inmann: "Contribution a l'etude des 'opsonines.' Proprietes opsonisantes des serums normaux," *Societe de Biologie*, 20 Avril, 1907, t. 62, No. 13, p. 683,

Levaditi et Inmann: "Contribution a l'etude des opsonines. Pouvoir opsonisant des serums normaux," *Societe de Biologie*, 27 Avril, 1907, t. 62, No. 14, p. 725.

Levaditi et Inmann: "Contribution a l'etude des opsonines. Opsonines des serums specifiques," *Societe de Biologie*, 4 Mai, 1907, t. 62, No. 15, p. 817.

Levaditi et Inmann: "Contribution a l'etude des opsonines. Mecanisme de l'opsonisation," *Societe de Biologie*, 11 Mai, 1907, t. 62, No. 16, p. 869.

Levaditi et Koessler: "Contribution a l'etude des opsonines normales. Anti-complements et anti-opsonines," *Societe de Biologie*, 20 Avril, 1907, t. 62, No. 13, p. 685.

Levaditi et Roche: "Les opsonines et le mecanisme de la crise dans la Tick-fever," *Societe de Biologie*, 13 Avril, 1907, t. 62, No. 12, p. 619.

Little, E. G.: "A Case of Lupus Vulgaris Treated with Tuberculin," *Brit. Jour. of Dermat.*, Sept., 1904.

Lohlein: "Phagocytose des Microbes Pathogenes," *Ann. l'Inst. Past.*, vol. 19, p. 647.

Lohlein, M.: "Einiges uber Phagocytose von Pest. und Milzbrandbacillen," *Centralblatt fur Bakt.*, Sept. 15, 1906, part 1, ref. vol. 38, Beilage p. 32.

Lohlein, M.: "Influence du serum normal sur le processus phagocytaire (Fixateurs normaux)," *Annales de l'Institut Pasteur*, November, 1906, vol. 20, No. 11, p. 939.

Lohlein, M.: "Uber A. E. Wright's Opsonins und seine therapeuitschen Bestrebungen bei Infektionskrankheiten," *Munch. med. Wochenschrift*, July 23, 1907, vol. 54, No. 30, p. 1473.

Lotti, C.: "Opsonine e Batteriotropine," *Riv. Crit. di Clin. Med.*, 1907, vol. 8, p. 87.

Lowenstein, E.: "Uber das Verhalten der Eiterzellen gegenuber den

Tuberkelbazillen," *Zeitschr. fur Hygiene u. Infektionskrankheiten*, 1906, vol. 55, p. 429.

Low, V. W.: "The Treatment of Surgical Tuberculosis," *Lancet*, July 14, 1906, vol. 2, p. 74.

Lyon, T. G.: "Note on a Case of Empyema Treated by Pneumococcus Vaccine," *Lancet*, June 24, 1905, vol. 1, p. 1708.

MacDonald, G.: "Origin and Course of Opsonins in Acute Pneumonia," *Path. Soc. Meeting*, Jan. 17, 1905.

Mace: "Opsonic Technic," *Cal. St. Jour. Med.*, Apr., 1907, vol. 5, p. 83.

Mackenzie, H.: "A Case of Cerebro-Spinal Meningitis or Spotted Fever Treated by Lumbar Puncture and Vaccine Injections, with Recovery," *Brit. Med. Jour.*, June 15, 1907, vol. 1, p. 1407.

Marie: "Sero-agglutination et opsonisation appliques au controle de la specificite du Bacillus paralyticans de F. Robertson," *Compte. Rend. Soc. de Biol.*, (Par.), 1907, lxiii.

Markl, G.: "Zur Kenntniss des Machanismus der kunstlichen immunitat gegen Pest," *Zeitschrift f. Hyg. und Infektionskrankheiten*, 1903, vol. 42, p. 244.

Massini: "Ueber Opsonine," (Uebersichtsreferat) *Med. Klin.* (Berlin), 1907, vol. 3, No. 18, p. 525.

May, A.: "The Manufacture of Bacterial Vaccines for Therapeutic Inoculation," *South African M. Rec.* (Cape Town), 1907, vol. 5, p. 165.

McArthur and Hollister: "Bacterial Vaccine Therapy in Surgery," *Surgery, Gynecology and Obstetrics*, Oct., 1709, vol. 5, No. 4, p. 373.

McFarland, Joseph: "The Nephelometer, an Instrument for Estimating the Number of Bacteria in Suspensions used for Calculating the Opsonic Index and for Vaccines," *Jour. Amer. Med. Asso.*, Oct. 5, 1907, vol. 49, No. 14, p. 1176.

McFarland and L'Engle: "Observations upon Phagocytic Power of the Blood of Normal Human Beings," *Proc. Path. Soc.* (Philadelphia), vol. 39, 1906.

McFarland and L'Engle: "Specific Nature of Opsonins," *Jour. Amer. Med. Asso.*, Oct. 5, 1907, vol. 49, No. 14, p. 1178.

Meakins, J. C.: "The Method of 'Fixation of Complement' in the Diagnosis of Meningococcus and Gonococcus Infections," *Johns Hopkins Hospital Bulletin*, June and July, 1907, vol. 18, p. 255.

Meakin and Wheeler: "Observations on the Opsonic Index of Patients Undergoing Sanatorium Treatment for Phthisis," *Brit. Med. Jour.*, Nov. 25, 1905, vol. 2, p. 1396.

Mennes, Fr.: "Das Antipneumokokken-Serum und der Mechanismus der Immunitat des Kaninchens gegen den Pneumococcus," *Zeitschrift fur Hyg. und Infect.*, 1897, vol. 25, p. 413.

Metchnikoff, Elie: "l'Immunite dans les Malladies Infectieuses. Paris, 1901.

Metchnikoff, Elie: "The Hygiene of the Tissues," *Lancet*, June 2, 1906, vol. 1, p. 1553.

Meyer und Bergell: "Ueber Typhusimmunisierung," *Ber. Klin. Wochenschrift*, May 6, 1907, vol. 44, No. 18, p. 568.

Micheli, J.: "Di Alcune Nuove Questioni Relative All'immunita," *Rivista Critica di Clin. Med.*, 1907, Nos. 7 and 8.

Miller, E. C. L.: "Directions for Determining the Opsonic Index of the Blood," *Therapeutic Gazette*, March 15, 1907, vol. 31, p. 173.

Miller, J.: "Opsonins," *Birmingh. M. Rev.*, lxii, 84-98.

Morton, J.: "Duration of Phagocytic Power of Human Leucocytes and

of Opsonic Power of Human Serum Outside the Body," Trans. Path. Soc (Chicago), April, 1905, vol. 6.

Moss, William Lorenzo: "Studies on Opsonins," *Johns Hopkins Hospital Bulletin*, June and July, 1907, vol. 18, p. 237.

Muir and Martin: "On the Combining Properties of Opsonins of Normal Serum," *Brit. Med. Jour.*, Dec. 22, 1906, vol. 2, p. 1783.

Muir and Martin: "On the Combining Properties of the Opsonin of an Immune Serum," Proc. Royal Soc., 1907, vol. 79, series B, 187.

Mumford, J. G.: "The Opsonins," *Bost. Med. and Surg. Jour.*, March 28, 1907, vol. 156, No. 13, p. 400.

Neufeld, F.: "Erwiderung auf Bemerkungen von Wright," *Deutsche med. Woch.*, Dec. 22, 1904, vol. 30, No. 52, p. 1929.

Neufield, F.: "Ueber die Ursachen der Phagocytose," *Arb. a. d. k. Gesundheitsamt* (Berl.), 1907, xxvii, 414-424.

Neufeld and Hune: "Ueber die Role des Phagocytose bei der Immunitat Gegen Cholera-Typhus und Paratyphus-bacillen," *Centralblatt fur Bakt.*, 1906, Part 1, Ref., vol. 38, p. 27.

Neufeld and Hune: "Untersuchungen ueber Bakterizide Immunitat und Phagozytose neben Beitragen zur Frage der Komplementablenkung," *Arbt. a. d. Kaiserl. Gesundheitsamte*, 25, 1, 1907.

Neufeld and Rimpau: "Ueber die Antikorper des Streptokokken-und Pneumokokken-Immunserums, *Deut. med. Woch.*, Sept. 29, 1904, vol. 30, p. 1458.

Neufeld and Rimpau: "Weitere Mitteilungen uber die Immunitat gegen Streptokokken und Pneumokokken," *Zeitschrift fur Hygiene und Infect.*, 1905, vol. 51, p. 283.

Neufeld und Topfer: "Ueber hamolytische und Hamotrope Sera," *Centralblatt fur Bakt.*, 1905, Part 1, Orig. vol. 38, p. 456.

Neumann, R. O.: "Untersuchungen uber 'Opsonine' und Phagozytose." *Zentralbl. f. Bakt.*, Originale, Part I, May 23, 1907, bd. 44, Heft. 1, p. 46.

Noguchi, H.: "On the Influence of the Reaction and of Dessication upon Opsonins," *Jour. Exp. Med.*, July, 1907, vol. 9, No. 4, p. 455.

O'Brien, J. D.: "Opsonins and the Use of Therapeutic Vaccines in Treating General Paralysis of the Insane," *Journal Amer. Med. Asso.*, June 29, 1907, vol. 48, No. 26, p. 2180.

Ochsner and Abelmann: "Case of Acne Varioliformis Treated by Wright's Vaccination Method." *Ill. Med. Journal*, June, 1907.

Ogilvy and Coffin: "A Preliminary Report on the Opsonic Index in Orthopedic Surgery." *The Post-Graduate* (New York), Oct., 1907, vol. 22, No. 10, p. 1033.

Ohlmacher, A. P.: "A Series of Medical and Surgical Affections Treated by Artificial Autoinoculation," *Jour. Amer. Med. Asso.*, Feb. 16, 1907, vol. 48, No. 7, p. 571.

Ohlmacher, A. P.: "Practical Bacterial Therapy and the Theory of Opsonins," *Ohio Med. Jour.* (Columbus), 1906-7, vol. 2, p. 549.

Ohlmacher, A. P.: "Some Suggestions Concerning the Terminology of Opsonic Theory and Practice," *Am. Med.*, 1907, New S., vol. 2, p. 141.

Ohlmacher, A. P.: "Therapeutic Bacterial Inoculation With and Without Opsonic Index as a Guide," *Jour. Mich. State Med. Soc.*, July, 1907.

Opie, Eugene L.: "Opsonins and Their Relations to the Diagnosis and Treatment of Bacterial Infection," *Yale Med. Jour.* (New Haven, Conn.), May, 1907, vol. 13, No. 7, p. 301. *Clin. Rev.* (Chicago), 1907-8, xxv, p. 15.

Opie, E. L.: "Opsonins of Inflammatory Exudates," *J. Exper.* M., 1907, ix, p. 515.

Paine and Morgan: "On the Value of a Serum (Doyen's), in Cases of Malignant Disease," *Lancet*, April 7, 1906, vol. 1, p. 955.

Painter, C. F.: "Experience with Opsonins and Bacterial Vaccines in the Treatment of Tuberculous and Non-tuberculous Arthritis," *Med. Comm. of Mass. Med. Society*, Vol. xx, No. 3, 615-635. *Boston M. and S. J.*, 1907, clvii, 621-626.

Pappenheim, A.: "Theoretische Serologie—Vorbemerkungen," *Folia Hœmatologica*, April, 1906, vol. 3, No. 5, p. 285.

Pardoe, J. G.: "The Treatment of Tuberculosis of the Urinary System by Tuberculin (T. R.)" *Lancet*, Dec. 16, 1905, vol. 2, p. 1766.

Park and Biggs: "The Opsonic Index as a Guide to Regulate the Use of Vaccines in the Treatment of Disease," *Jour. Med. Research*, Oct., 1907, vol. 17, No. 1, p. 77.

Paton, D. M.: "Notes on the Passive Raising of the Opsonic Index by Immune Serums," *Med. Press and Circ.* (London), 1907, N. S., vol. 83, p. 648.

Pernet and Lemare-Bunch: "The Opsonic Treatment of Certain Diseases of the Skin," *Brit. Jour. of Dermatology*, 1906.

Polano, Oskar: "Ueber Prophylaxe der Streptokokkeninfektion bei Geburt und Operation durch aktive Immunisierung," *Zeitschrift fur Geb. und Gyn.*, vol. 56, No. 3, p. 463.

Porter, Langley: "A Few Words on Opsonins," *California State Journal of Medicine* (San Francisco), April, 1907, vol. 5, No. 4, p. 82.

Pottenger, J. E.: "A Convenient Method of Obtaining Clump-free Emulsion for Opsonic Work," *Jour. Amer. Med. Asso.*, April 13, 1907, vol. 48, p. 1269.

Pottenger, J. E.: "The Opsonic Index: its Possibilities and Limitations." *Southern California Pract.* (Los Angeles), April, 1907.

Potter, Ditman, and Bradley: "Review of the Work upon the Opsonic Index (Wright and Douglas), in Tuberculosis," *Am. Jour. Med. Sci.*, August, 1906, vol. 132, p. 186.

Potter, Ditman, and Bradley: "The Opsonic Index in Medicine," *Jour. Amer. Med. Asso.*, vol. 47, p. 1722 and p. 1793.

Potter, N. B. and Krumwude, G.: "Some Observations in Pneumonia and in Four Streptococcus Infections," *J. Inf. Dis.*, 1907, iv, p. 601.

Power, H. D'A.: "The Opsonins," *Pacific Med. Jour.* (San Francisco), 1906, vol. 18, p. 670.

Rankin and Martin: "Observations on the Effects of Fasting Upon the Opsonic Power of the Blood to Staphylococcus Aurens (Abstr.). *Proc. Soc. Exper. Biol. and Med.* (N. Y.), 1906-7, vol. 4, p. 81.

Reed, J. V.: "General Considerations of Opsonins," *Ind. Med. Jour.* (Indianapolis), 1906-7, vol. 25, p. 481.

Reque, H. A.: "Some Observations on Phagocytosis of Diphtheria Bacilli." *Jour. of Infect. Dis.*, May, 1906, p. 441.

Risquez: "Reglas para la Determinacion del Indice Opsonico de la Sangre: Informacion de Actualidad." *Rev. Esp. Med.* (Madrid), 1907, vol. 10, p. 256.

Ritchie, James: "Discussion on Immunity," *Brit. Med. Jour.*, Sept. 10, 1904, vol. 2, p. 557.

Riviere, Clive: "The Vaccine Treatment of Tuberculosis in Children," *Brit. Med. Jour.*, April 13, 1907, vol. 1, p. 859.

Rodd, M. L. B.: "Three Cases Treated by Bacterial Vaccines." *Brit. Med. Jour.*, July 27, 1907, vol. 2, p. 204.

Romme, R.: "Les Opsonines et la Phagocytose," *La Presse Med.*, 1906, vol. 14, p. 360.

Rosenow, E. C.: "The Role of Phagocytosis in the Pneumococcidal Action of Pneumonic Blood," *Jour. of Infect. Dis.*, 1906, vol. 3, p. 683.

Rosenow, E. C.: "Human Pneumococcal Opsonin and Antiopsonic Substance in Virulent Pneumococci," *Jour. Infect. Dis.*, June 15, 1907, vol. 4, No. 3, p. 285.

Rosenthal, W.: "Die Wrightsche Opsoninlehre und ihre klinische Verwertung zu diagnostischen und therapeutischen Zwecken," *Med. Klinik*, April 14, 1907, vol. 3, No. 15, p. 424.

Ross, G. W.: "Opsonic Theory and its Practical Application to Medicine and Surgery," *Brit. Med. Jour.*, July 7, 1906, vol. 2, page 1452; *Canada Lancet*, Jan., 1907, p. 403.

Ross, Geo. W.: "Opsonins and Bacterial Vaccines," *Brit. Med. Jour.*, Nov. 24, 1906, vol. 2, page 1452; *Canada Lancet*, Jan., 1907, p. 403.

Ross, G. W.: "Opsonins and the Practical Results of Therapeutic Inoculation, with Bacterial Vaccines," *Jour. Amer. Med. Asso.*, Oct. 12, 1907, vol. 49, p. 1245.

Rotch and Floyd: "The Opsonic Index and the Tuberculin Test in Diagnosis and Treatment of Early Tuberculosis in Children," *Jour. Amer. Med. Asso.*, Aug. 24, 1907, vol. 49, p. 633.

Rubin, G.: "The Influence of Alcohol and Chloroform on Phagocytosis in Vitro," *Jour. Amer. Med. Asso.*, April 27, 1907, vol. 48, No. 17, p. 1432.

Ruediger, G. F.: "The Mechanism of Streptococcus Infection," *Jour. Amer. Med. Asso.*, Jan. 21, 1905, vol. 44, p. 198.

Ruediger, G. F.: "Further Studies on Streptococcus Infection," *Jour. Infec. Dis.*, 1906, vol. 3, No. 1, p. 156; *Jour. Amer. Med. Asso.*, Jan. 13, 1906, vol. 46, p. 108.

Ruediger and Davis: "Phagocytosis and Opsonins in Lower Animals," *Jour. Infec. Dis.*, Chicago, June 15, 1907, vol. 4, No. 3, p. 333.

Russell, F. F.: "Studies on the Specificity of Opsonins in Normal and Immune Serum," *Johns Hopkins Hospital Bulletin*, June and July, 1907, vol. 18, p. 252.

Sauerbach, Ernst: "Neue Tatsachen und Theorien in der Immunitatsforshung," Sonder-Abdruck aus Lubarsh-Ostertag Ergebnisse, 1907, vol. 11, Wiesbaden.

Sawtchenko, J. G.: "Du Role des Immunesines (Fixateurs) dans la Phagocytose," *Ann. de l'Inst. Past.*, 1902, vol. 16, p. 106.

Sawtchenko et Melkich; "Etude sur l'immunite dans la Fievre Recurrente," *Ann. l'Inst. Past.*, 1901, vol. 15, p. 497.

Schorer, E. H.: "The Opsonic Index in Erysipelas and its Relation to Treatment by Inoculation of Killed Streptococci," *Amer. Jour. Med. Sci.*, Nov., 1907, vol. 134, No. 5, p. 728.

Shaw, C. J.: "Opsonic Index to Various Organisms in Sane and Insane," *Lancet*, May 11, 1907, vol. 1, p. 1287.

Simon, Ch. E., in Association with R. V. Lamar and W. W. Bispham: "A Contribution to the Study of the Opsonins," *Jour. Exp. Med.*, Dec., 1906, vol. 8, p. 651.

Simon, Ch. E.: "The Percentage Index versus the Bacillary Index in the Estimation of the Opsonins," *Jour. Amer. Med. Asso.*, Jan. 12, 1907, vol. 48, p. 139.

Simon, Ch. E.: "A Further Contribution to the Knowledge of the Opsonins," *Jour. Exp. Med.*, Sept., 1907, vol. 9, No. 5, p. 487.

Simon and Lamar: "A Method of Estimating the Opsonic Content of Blood and other Fluids," *Johns Hopkins Hospital Bulletin*, Jan., 1906, vol. 17, No. 178, p. 1.

Simonds, J. P.: "The Effect of the Injection of Killed Streptococci on the Streptococcic index of Normal Rabbits," *J. Infect. Dis.*, 1907, iv. 595.

Smith, D. T.: "Opsonins in Surgery," *Med. Century* (New York and Chicago), 1907, ix.

Smith, H. W.: "Observation on Vaccine Treatment in Sir A. E. Wright's Laboratory," *U. States Nav. M. Bull.* (Wash.), 1907, i, p. 112.

Smith, J. H.: "The Opsonic Index," Ophthalmoscope (London), 1906, vol. 4, p. 513.

Snell, S.: "A Case in which the Eye Ball was Filled with Tubercle," *Lancet*, Feb. 16, 1907, vol. 1, p. 429.

Squire, J. E.: "Opsonins in Relation to the Specific Treatment of Tuberculosis," *Brit. Med. Jour.*, June 15, 1907, vol. 1, p. 1417.

Stark, Jos.: "Surgical Tuberculosis and the Opsonic Index," *Brit. Med. Jour.*, June 29, 1907, vol. 1, p. 1536.

Stevens, R. H.: "Eight Months' Experience in the Treatment of Some Skin and Infectious Diseases by Opsonins," *N. Eng. M. Gaz.* (Bost.), 1907, xlii, p. 367.

Steward, G. E.: "The Influence of Alcohol on the Opsonic Power of the Blood," *J. Inebr.*, Bost., 1907, xxix, 197-203.

Stewart and Richie: "The Opsonic Index in the Diagnosis of Tuberculosis," *Brit. Med. Jour.*, July 14, 1906, vol. 2, p. 87.

Stewart and Ritchie: "The Tuberculous Opsonic Index," *Brit. Med. Jour.*, March 16, 1907, vol. 1, p. 626.

Stitt, E. R.: "Notes on Opsonins and Their Present Diagnostic and Therapeutic Status," *U. States Nav. M. Bull.*, 1907, i, p. 105.

Stone, B. H.: "The Principles and Practice of Opsonic Therapy," *Internat. J. Surg.* (New York), 1907, vol. 20, p. 172.

Strubel, "Ueber Opsonine," *Munch. Med. Wochenschrift*," Oct. 1, 1907, vol. 54, No. 40, p. 2004.

Taylor, Alice: "The Opsonic Index and Agglutination in Cerebro-spinal Meningitis," *Lancet*, July 6, 1907, vol. 2, p. 16.

Thomas, Benj. A.: "Variability and Unreliability in the Determination of the Opsonic Index," *Jour. Amer. Med. Asso.*, Oct. 12, 1907, vol. 49, p. 1249.

Thorne, R. T., "Antistaphylococcic Vaccine in the Treatment of Furnunculosis," *Brit. Med. Jour.*, Feb. 23, 1907, vol. 1, p. 436.

Thurston, H. S.: "Practical Application of Opsonins," *Ind. Med. Jour.* (Indianapolis), 1906-7, vol. 25, p. 485.

Tunnicliff, R.: "Streptococco-opsonic Index in Scarlatina," *Jour. Infect. Dis.*, June 15, 1907, vol. 3, p. 304.

Tunnicliff and Davis: "Spontaneous Phagocytosis of Fusiform Bacilli and Influenza Bacilli," *Jour. Infect. Dis.*, Chicago, January, 1907, vol. 4, No. 1, p. 66.

Turton and Appleton: "The Relative Opsonic Power of the Mother's Blood Serum and Milk," *Brit. Med. Jour.*, April 13, 1907, vol. 1, p. 865.

Turton and Parkin: "A Series of Cases Treated by the Injection of Bacterial Vaccines," *Lancet*, Oct. 27, 1906, vol. 2, p. 1130.

Urwick, R. H.: "Observations on the Opsonic Power of People Suffering from Tuberculosis," *Brit. Med. Jour.*, July 22, 1905, vol. 2, p. 172.

Varney, H. R.: "Opsonic Therapy in Skin Diseases," *Jour. Amer. Med. Asso.*, July 27, 1907, vol. 49, p. 316.

Verney, L.: "Le Opsonine," *Il Policlinico* (Rome) *Sez. Practica*, 1907, fasc. 40 and 41, p. 1.

Vogt, K.: "Einiges uber die Wright'sche opsonintheorie und deren Praktische Verwendung," *Med. Woche* (Halle), 1907, viii, 307; 317; 327.

Walker, C. E.: "Observations on the Life-history of Leucocytes," *Proc. Roy. Soc.*, 1906, Series B, vol. 78, p. 53; 1907, vol. 79, p. 491; 1907, vol. 79, p. 495.

Walker, E. L.: "The Relative Influence of the Blood Fluids and the Bacterial Toxins on Phagocytosis," *Jour. Med. Res.*, Nov., 1905, vol. 14; (New S., vol. 9), p. 173.

Walker, R. E.: "Observations on Phagocytosis in Relation to the Opsonic Index," *Jour. Med. Res.*, July, 1907, vol. 16, No. 3, p. 521.

Walker, R. E.: "The Bacterial Suspension in the Determination of the Opsonic Index," *Physician and Surgeon* (Detroit and Ann Arbor), 1907, vol. 29, p. 20.

Walters, W. H.: "The Opsonic Index in its Relation to Inoculation by Bacterial Toxins," *N. Eng. M. Gaz.* (Bost.), 1907, xlii.

Webb, G. B.: "Wright's Latest Opsonic and Bacterial Vaccine Work," *Colorado Med.* (Denver), Jan., 1907, vol. 4, No. 1, p. 22.

Weinstein, E. M.: "Ueber die Grundlagen und Anwendung der Wright'schen Opsonintheorie," *Berl. Klin. Woch.*, July 30, 1906, vol. 43, No. 30, p. 1007.

Weinstein, E. M.: "Ueber die Heilung post-operativer Fistulen der Bauchhohle durch Vaccinebehandlung nach dem Wright'schen Prinzip," *Berl. Klin. Woch.*, 1906, vol. 43, No. 39, p. 1275.

Wells, J. H.: "On the Treatment of Bacterial Diseases by the Inoculation of the Corresponding Vaccines," *Lancet*, Oct. 20, 1906, vol. 2, p. 1072.

Western: "The Influence of Potassium Iodide on the Resistance of the Blood Fluids to Staphylococcus Albus," *Brit. Jour. of Derm.*, August, 1905.

White, A. H.: "The Opsonic Index in Relation to Tuberculous Peritonitis," *Dublin Jour. Med. Sci.*, April, 1906.

White, A. H.: "On the Opsonic Index and the Therapeutic Inoculation of Bacterial Vaccines," *Tr. Roy. Acad. M. Ireland* (Dublin), 1907, xxv, 379-405.

Wilson, A.: "About Opsonins," *Cornhill Mag.*, 1907, p. 92.

Woldert, A.: "What is meant by the Opsonic Index in Medicine: Opsono-Index Therapy," *Texas M. News* (Austin), 1906-7, vol. 16, p. 282.

Wolf, H. E.: "Observations on the Opsonic Index and the Antipneumococcic Power of the Blood in Pneumonia," *Jour. Infec. Diseases*, Oct., 1906, vol. 3, No. 5, p. 731.

Woodhead and Mitchell: "Opsonins in Milk," *Jour. of Path.*, 1907, vol. 11, No. 4.

Wright, A. E.: "Notes on the Treatment of Furunculosis, Sycosis, and Acne by the Inoculation of a Staphylococcus Vaccine, and Generally on the Treatment of Localized Bacterial Invasions by Therapeutic Inoculations of the Corresponding Bacterial Vaccines," *Lancet*, March 29, 1902, vol. 1, p. 874.

Wright, A. E.: "On Some New Procedures for the examination of the Blood and Bacterial Cultures," *Lancet*, July 5, 1902, vol. 2, p. 11.

Wright, A. E.: "A Lecture on Therapeutic Inoculations of Bacterial Vaccines, and Their Practical Exploitation in the Treatment of Disease," *Brit. Med. Jour.*, May 9, 1903, vol. 1, p. 1069.

Wright, A. E.: "A Note on the Serum Reaction of Tubercle, with Special Reference to the Intimate Nature of Agglutination Reactions Generally

and to the Therapeutic Inoculation of the New Tuberculin," *Lancet*, May 9, 1903, vol. 1, p. 1299.

Wright, A. E. "On Some Further Improvements in the Procedures for Testing and Judging by the Naked Eye of the Agglutinating and Bacteriolytic Effects Exerted by the Sera of Patients Suffering from, or Preventively Inoculated Against, Typhoid Fever, Malta Fever, and Tuberculous Affections," *Lancet*. July 25, 1903, vol. 2, p. 214.

Wright, A. E.: "On Some Further Antityphoid Inoculation," London, 1904.

Wright, A. E.: "On Certain New Methods of Blood Examination with Some Indications of their Clinical Importance," *Lancet*, Jan. 23, 1904, vol. 1, p. 215.

Wright, A. E.: "On Antityphoid Inoculation, and on the Principles of Protective Inoculation and the Physiology of Immunization," *The Practitioner*, Jan., Feb., and March, 1904, pp. 118, 191, and 350.

Wright, A. E.: "On the Treatment of Acne, Furunculosis and Sycosis by Therapeutic Inoculations of Staphylococcic Vaccine," *Brit. Med. Jour.*, May 7, 1904, vol. 1, p. 1075.

Wright, A. E.: "Pathological Suggestions," *Lancet*, July 9, 1904, vol. 2, p. 73.

Wright, A. E.: "A Lecture on the Inoculation Treatment of Tuberculosis," *Clinical Journal*, Nov. 9, 1904.

Wright, A. E.: "On the Action Exerted upon the Staphylococcus Pyogenes by Humen Blood Fluids, and on the Elaboration of Protective Elements in the Human Organism in Response to Inoculation of a Staphylococcus Vaccine," *Proc. Roy. Soc.*, 1904, vol. 74, p. 147.

Wright, A. E.: "Ueber die Antikorper des Streptococcen- und Pneumococcen-Immunserums," *Deutsche med. Woch.*, Dec. 22, 1904, vol. 30, No. 52, p. 1929.

Wright, A. E.: "On the General Principles of the Therapeutic Inoculations of Bacterial Vaccines as Applied to the Treatment of Tuberculous Infections," *Lancet*, Dec. 2, 1905, vol. 2, p. 1598; Dec. 9, vol. 2, p. 1674.

Wright, A. E.: "On the Foundations of Serum Therapy," *Clinical Jour.*, May 16, 1906.

Wright, A. E.: "The Opsonic Theory," *The Canadian Practitioner and Review*, Nov., 1906, vol. 31, No. 11, p. 605; *Pediatrics*, 1907, vol. 19, p. 6.

Wright, A. E.: "Principles of Vaccine Therapy," *Jour. Amer. Med. Asso.*, Aug. 10 and 17, 1907, vol. 49, pp. 479 and 567.

Wright, C.: "Opsonins and the Rontgen Ray Treatment," *Arch. of the Rontgen Ray*, Dec., 1905.

Wright and Douglas: "An Experimental Investigation of the Role of the Blood Fluids in Connection with Phagocytosis," *Proc. Roy. Soc.*, 1903, vol. 72, No. 483, p. 357.

Wright and Douglas: "Further Observations on the Role of the Blood Fluids in Connection with Phagocytosis," *Proc. Roy. Soc.*, 1904, vol. 73, p. 129.

Wright and Douglas: "On the Action Exerted upon the Tubercle Bacillus by Human Blood Fluids, and on the Elaboration of Protective Elements in the Human Organism in response to Inoculations of a Tubercle Vaccine," *Pro. Roy. Soc.*, 1904, vol. 74, p. 160; *Lancet*, Oct. 22, 1904, vol. 2, p. 1138.

Wright and Douglas: "On the Action Exerted upon the Staphylococcus Pyogenes by Human Blood, and on the Elaboration of Protective Elements in the Human Organism in response to Inoculations of a Staphylococcus Vaccine," *Proc. Roy. Soc.*, 1904, vol. 74, p. 147.

Wright, Douglas, Freeman, Wells, Fleming, and others: "Studies in con-

nection with Therapeutic Immunization," *Lancet*, Nov. 2, 1907, vol. 2, p. 1217.

Wright and Lamb: "Observations bearing on the Question of the Influence which is Exerted by the Agglutinins in the Infected Organism," *Lancet*, Dec. 23, 1899, vol. 2, p. 1727.

Wright and Reid: "Two Cases of Cholecystitis Treated with Inoculations of Bacillus Coli," *Lancet*, Jan. 20, 1906, vol. 1, p. 159.

Wright and Reid: "On the Possibility of Determining the Presence or Absence of Tubercular Infection by the Examination of a Patient's Blood and Tissue Fluids," *Proc. Roy. Soc.*, 1906, ser. B, vol. 77, p. 194.

Wright and Reid: "On Spontaneous Phagocytosis, and on the Phagocytosis which is obtained with the Heated Serum of Patients who have Responded to Tubercular Infection, or, as the case may be, to the inoculation of a Tubercle Vaccine," *Proc. Roy. Soc.*, Jan., 1906, ser. B, vol. 77, p. 211.

Wright and Windsor: "On the Bactericidal Effect Exerted by Human Blood on Certain Species of Pathogenic Microorganisms and on the Anti-bactericidal Effects Obtained by the Addition of the Blood in Vitro of Dead Cultures of Microorganisms in Question," *Jour. of Hyg.*, Oct., 1902, vol. 2, No. 4, p. 385.

Wynn: "Opsonic Treatment of Actinomycosis of the Lung," *Brit. Med. Jour.*, May 11, 1907, vol. 1, p. 1119.

Yorke, W.: "Observations on the Behavior of Opsonins and Serum Proteids during Pressure Filtration," *Bio-Chemical Journal*, 1907, vol. 2, p. 357.

Yorke and Smith: "The Effects of Injection of Antitoxic and Antibacterial Sera on the Opsonic Power of the Blood," *Bio-Chemical Journal*, 1906, vol. 1, p. 341.

Yorke and Smith: "Evidence of the Existence of a Pre-Opsonin in Normal Serum, Convertible into Active Opsonin by the Addition of any Microorganism —Lowering and Ultimate Suppression of Opsonic Power of Normal Serum to all Organisms, by the Addition of One," *Bio-Chemical Journal*, 1906, vol. 2, p. 74.

Zlatogorow, S.: "Ueber Streptokokken bei Scharlach," *Wratschebuaja Gazeta*, 1906, No. 12.

THE STUDY OF TYPES IN THE PRESENTATION OF BOTANY AND ZOOLOGY IN SECONDARY SCHOOLS.

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I assume as the basis for this discussion, that the teaching considered in this paper is educational in its nature rather than professional. I mean by this that it shall be for the ultimate purpose of training the mind to do better the things that all minds can do in some degree rather than to accumulate a fund of information to be used in the practice of a profession. The psychological movement of the learner rather than the logical development of the subject is the thing that is of the first importance, and is the chief factor in determining the method to be employed.

Permit me, also, to state that in all my illustrations I shall have in mind the teaching of science in high schools. If the teaching of scientific subjects in colleges and professional schools were to be considered, the illustrations and the basic propositions would need very considerable modifications.

The greatest contribution of science to education is the scientific method. The scientific method is not a method of teaching, but it is a method of thought, and is capable of universal application. It is called the scientific method because it has been chiefly developed in scientific subjects by scientific men. Its importance is so great and so fully recognized that we are continually finding the scientific method applied to subjects formerly considered most remote from scientific facts.

In its essential features, the scientific method proceeds in an orderly way from the study of an individual to related individuals. By a perception of the resemblances and differences existing among individuals, the concept of a class is formed, and thereafter related individuals are grouped into the classes previously formed. By this process we are compelled to recognize the logical sequence and the relative significance of each before we can classify it.

It will be seen that in the scientific method of study, an individual is the first thing to be considered. From this fact the scientific method is sometimes regarded as an example of induction. In reality, the scientific method is quite as much deductive as it is inductive, but the starting point is the same as in a case of pure induction. This individual which is taken as the starting point may be called a type, since it always embodies the characteristics of the group that is founded upon it. A type, however, may mean much more than the individual that is studied. It necessarily involves all the characters that enter into the concept of the class but it should be one that contains the average characters of the class. Individuals of the same kind are not all alike. Variations occur that make them individuals. These variations are quantitative in their nature, and in some individuals are much greater than they are in others. In any group of individuals that are combined into a class, there will always be extremes of variation, and an average point or norm from which variations occur. In the vicinity of this norm will be found the greater number of individuals that constitute the class. It is this average, this point of departure, this possessor of the common

characters in the least variable degree that may stand for the type of the class. It will be seen then, that the selection of an individual to stand as the type of a group is a matter demanding considerable care. It certainly would be very unwise to select as the type for study one of the most aberrant or divergent forms in the group.

It is evident that the selection of an individual to stand as a type will depend upon what it typifies. An individual is not a type unless it stands in the mind for a class, or stands as the representative of a group all of which have common characteristics. We come at once then to classification as an element in scientific study. Classification is implied in almost every operation of the mind above the simplest. It is implied in every act of judgment. Whenever we use a common noun we make use of classification or its results. Every catalogue, every index, every table of contents, the arrangements of our houses and streets attests the necessity we feel ourselves under for classifying objects. It is a universal process of thought, and is common to all human minds. It is this process of classification that constitutes science and renders possible scientific knowledge.

Classification of a series of objects is the ideal or the actual arrangement of those together that are alike and the separation of those that are unlike. It enables us to do two things. First, it enables us to retain in mind the characters of many objects at once, as well as to infer from things known, unknown correlative characteristics. It is a labor saving process. It conserves mental effort, and this economy of mental effort is perhaps the most important principle of education. It is the thing that largely constitutes the difference between a mind of great power and one of little power.

But classification does something more than this. Classification discloses to us the correlations or laws of union of properties and circumstances. It is only when we make a proper classification that these laws appear. We are inclined to think that for every series of objects there is one system of classification that is best, which we call the natural system, and much energy is devoted to the discovery of that system. The so-called natural system of classification in animals and plants is a genealogical system intended to show the relationship by descent of the individuals classified. It discloses the general law of descent and the kinship existing among the different plants and animals. This system is not yet complete. We do not know enough about animals and plants to adjust them satisfactorily in their places. But there is no question that the arrangement of organized beings in the natural system of classification has been productive of the greatest good in the development of our scientific knowledge, and in disclosing some of the profoundest and most far-reaching truths.

But the natural system of classification is not the only one that may be used to advantage, nor the only one that is still employed in classifying animals and plants. Other systems of classification disclose other laws than those of descent. We still have and still need the classifications of geographical regions, of temperature zones, of life habits, of geological horizons, of physiological functions. Each of these classifications is necessary and will always be used because each discloses natural laws that constitute an essential part of scientific knowledge.

I think I do not overestimate the importance of the study of classification as an element in education. There are certain elements of dynamic thought involved in classification that are positively fundamental. Somewhere in the life of a student there must be a place in which the processes and methods of classification are consciously worked out. If this can be done

in one or two subjects, the principle of classification can be applied to other subjects and be used as a tool to make further acquisitions of power in other directions.

Botany and zoology are the classificatory sciences par excellence. Here the principles of classification have been worked out with a minuteness and fullness of detail observed in no other subjects. Here if anywhere the student must get his knowledge of those principles. In my opinion, botany and zoology must rest their claims for introduction into a course of study upon the fact that they are classificatory sciences, and any attempt to substitute some other element than classification as a basis for the work in those subjects, is to discard an element of greater importance for one of a less.

I am not unmindful of the fact that both subjects include many departments in which the element of classification is not at all the conspicuous process. Such are the departments of physiology, histology, cytology, paleontology, embryology and ecology. Each of these may be taken as the basis of knowledge of animals and plants. My contention is that in an elementary course, where the purpose is purely educational, it is highly injudicious to make anything but taxonomy the basis of the work. The other departments are tributary to this and should be so recognized. They are highly specialized departments, and can scarcely be studied in their full significance without some knowledge of the taxonomic relations of the forms used as types.

This digression upon classification started from the statement that the selection of a type depends upon what it typifies. In botany and zoology we have classified groups of different rank, rising through the series of individual, species, genus, family, order, class, branch and kingdom, each with many subdivisions. A complete scheme of systematic study would lead us to select a type of a species, a type of a genus, a type of a family, a type of an order, a type of a class, a type of a branch and a type of a kingdom. The logical sequence and the relative significance of these groups can be determined only if our first animal studied shall serve successively as the type of each. By this process we begin with the individual as an individual and rise by successive generalizations through the less comprehensive groups, to the all-inclusive group of animal kingdom. I know of no one who will undertake, with a high school class, to use an amoeba as the type of a species, a genus, a family, an order or even a class. It is generally used as a type of animal, thus beginning with the most comprehensive group and proceeding in a deductive order, or not obtaining from the subject the content I would suggest as one of the most important things to be obtained from it, viz., a knowledge of the principles of classification and the full significance of type study.

Besides this, we must decide of what an individual shall be a type before we can decide what characters are of sufficient importance to demand the attention of the learner. An animal is at first only an individual, and as such has some thousands of characteristics. No one will be rash enough to undertake a complete catalogue of all the characters possessed by a single individual. Different writers of laboratory guides will cause a pupil to see different numbers of these characteristics, some more and some fewer. A college student may be called upon to see fifty and a pupil in the grammar grades to see only five. But upon what basis is the number of characteristics to be observed determined. There is scarcely more value in seeing fifty than in seeing five, unless the characters to be observed are selected with a reasonable and sufficient end in view. To add

the observation of non-significant characters to non-significant characters is unnecessary waste of energy. They will never become significant.

I have stated now what a type is, and the principles that shall govern both our selection of the type, and our selection of the characters that are to be observed in the study of each. My second proposition is that different things selected as types should be related to each other in such a way that the comprehension of the relations is not too difficult for the learner. The types must not be too widely separated from each other. The related forms must be studied. If this is not done there is little value in the study of a type. All thinking consists in the perception of relations between things. So numerous and so diverse are the relations existing in the universe, that we may say that education consists in the training of the mind to perceive relations. Any mind can see some of the most evident relations, but the mind of the greatest philosopher is incapable of recognizing some of those that exist. In order to train the mind to perceive relations, it must be set to perceiving them, and the difficulties must be graded according to the capacity of the mind to be taught. It is in the proper gradation of difficulties that teachers are likely to make mistakes. Especially is this true in the teaching of science whose pedagogics is so insufficiently worked out. We have no adequate statement that I have been able to find of the psychology of laboratory science, and no serious attempt has been made to frame a course of study in science in terms of the psychological movement of the learner. Our books of method in science are books of devices, or method in the most limited sense.

I would not have it understood that we study only the dead forms instead of the living beings, as is sometimes charged against this kind of work. The living activities are just as much a character of the type as the morphological structures. But the dead body of a beetle is a living thing in the sense that every part has been produced by the life of the animal and had some part in the life that the animal lived. We study the legs because the animal moves with them; the wings because it flies with them; the mouth parts because it bites with them. And so it is with every part; each part has some meaning in the life of the animal and it is the object of study to interpret that meaning.

Just here I should like to pause long enough to comment upon the value that exists in systematic work in botany and zoology. It is a kind of work that has of late fallen very much into disfavor, and very properly too, in consequence of the great abuse to which it has been subjected. The marks that are used to discriminate genera and species are apparently so trivial that they seem ludicrous. I merely wish to suggest that the variation in physiological function and life habits are usually much more pronounced than are the morphological differences that can be quantitatively stated and used to discriminate species. Even among individuals of the same species such variations in personality exist that we need to study many individuals of a species in order to obtain an insight into the psychology of the species. Also I would suggest that all the most delicate work of the embryologist, the histologist, the ecologist, everybody who contributes to the knowledge we possess of an individual of a particular species only helps us to arrive at a better understanding of the relationship that exists among the various groups of animals and plants, which is precisely the thing that the systematist attempts to do in a rough and ready way. Minute discriminations such as the systematist makes are necessary. Who would imagine the minute differences in structure would be correlated with

such tremendous consequence in physiology as exists between Culex, Anopheles and Stegomyia. The common mosquito which is only a nuisance, the other the bearer of malaria, and the third the devastating disseminator of yellow fever. I have known a professor of biology in a great university, to teach his classes to call Pectinatella an alga. It is unsafe to generalize without definite knowledge, and ludicrous errors multiply when scientific methods are abandoned for prospects believed to be more alluring.

My third proposition is that the study of types is necessary for the purpose of economizing effort. This is merely a corollary to our discussion of classification. I doubt if there is a more important principle in education than the one indicated by the phrase economy of effort. I believe it can be shown that the essential difference between the great intellect and the common one is embodied in the phrase economy of effort, and that the most important mental processes are those that most efficiently conserve mental work.

A type from its very nature stands for a class. Everything that we may predicate of the type as distinguished from the individual, we may predicate of the class. We need not then examine all the members of the class in order to know what its properties are. Type study is a substitute for perfect induction, and while it has serious limitations, its advantages are very great for the economy of effort. The great extension of knowledge in every direction has necessitated a development of some method of using it. Otherwise it becomes unwieldy and a student is overwhelmed by its very profusion. Type study is the method by which this great wealth of knowledge can be acquired and made available for service. The idea of a group that will include the various individuals studied is obtained by comparison of their properties, and selecting from the entire number those in which the individuals agree. The concept of the more comprehensive group is obtained by observing the resemblances that exist among the types of the less comprehensive groups. This process is called generalization, and is of essential importance. In fact, most of the other operations of the mind may be regarded as tributary to this one function. It necessitates a good many preliminary operations; abstraction, analysis, discrimination and comparison always precede.

The perception of resemblances is a more difficult process and a higher order of thought than is the perception of differences. There are acute minds that have in a marked degree the power to see differences, but whose ability to see resemblances is exceedingly limited. In order to generalize, we must often see a logical identity existing in objects that on first examination appear to be wholly unlike. Paradoxes are fused into a unity, and things that seem to be so diverse as to render an assertion of their identity absurd, are seen to be essentially the same.

Every mind must generalize, and every mind has the power so to do, but the differences in this power, in different individuals are very great. It is a power that can be exercised safely only with much caution and after long training. Every great advance in thought has followed a wider and more far-reaching generalization. Those who are capable of making such generalizations are the philosophers and leaders of thought. In natural science we are taught consciously how generalizations are made, and the necessary cautions to be employed. Science than, is the great training ground of those who generalize, and from the ranks of scientific men, or those trained in scientific methods, the philosophers of the future are sure to come.

In the collection of material, the mind becomes buried under a mass of details. We must select out of this mass of material particular things that

we can examine fully, and generalize from them. The selected forms are types and their selection is necessary to enable us to generalize.

My fourth proposition is derived from the third. Economy of effort is obtained by comparing the second type studied with the first. It will be remembered in our previous illustration that the elementary type, or first form studied was examined as an individual. There is no economy of effort if the second type is studied *de novo* in the same way. Here is the criticism upon the kind of teaching often called type-study, but which has no claim to the name. The study of an individual is not type study, unless related individuals are studied, whose relations to it make it a type. This, I take it, is the source of most of the criticisms made upon type study, and it was to deprive it of the name improperly applied that this paper was prepared. The second thing must be studied by comparison with the first. Ordinarily, its individual characters need not be noticed, but only the specific and generic characters. That is, the characters that are like or unlike those selected for study in the first.

The former practice in beginning the study of botany was to learn lessons from Gray's botany, and after they had been well memorized, then to go to the flowers, and apply to them the name of parts that we had learned in the lessons. I have a profound respect for Gray's botany, but not so much for the teachers who used it in that way. They failed entirely to grasp the significance of type study.

Suppose that we decide that it is a proper part of botany to study flower structure. If one of the buttercups is available, it will serve well as a type. A short time will suffice to fix the fundamental characters of this flower. The evening primrose in the next lesson will embody the same essential elements of flower structure with modifications, the most important of which is the fact that the ovary is compound. The compound ovary is about the only thing in the flower that must be learned new, and this is learned because it is a difference from the type form of a flower previously studied. A study of the Jimpson weed introduces to the monopetalous corolla, a clover to the papilionaceous corolla, diadelphous stamens and the clustered head. Other ideas in flower structure can be simply exemplified by a proper selection of types, so that ten lessons treated in the most economical way will give a student a better idea of flower structure and plant morphology than we obtained in three months in the old way.

It was formerly the custom, now happily abandoned, in studying flowers to have a series of blank forms with many descriptive words, and the pupil was expected to underscore the words that fitted the flower he had in hand. You will see that in this process each flower was studied by the same pattern that the first one was, so there was no economy of mental effort, although there might be a saving of ink in consequence of not having to write the descriptive words.

By the use of properly selected type forms, it is easily possible to study a dozen related individuals with no more effort than it took to study the one used as the original type, and do it as well. I have often observed that a class in the first year of a high school course will learn as much about a cricket, see just as many characteristics and see them just as well in two days as they saw in the first specimen studied, a grasshopper or a beetle, in five weeks. A common explanation by unthoughtful people is that the powers of observation are cultivated by the study of natural science to such an extent that they become able to see more in a given time. The powers of observation, as a reason for studying natural science has been so much overworked that I

always feel suspicious of the knowledge or the sincerity of anyone who gives that as a reason why natural science should be studied. The power to observe comes largely from the related facts previously known.

My fifth proposition is that type study is almost universal in its application. It is a conspicuous feature in the scientific method, and is capable of application with all its advantages wherever the scientific method can be applied. I have been using illustrations drawn from the classificatory sciences, but it is now being applied to geography, to sociology and to almost every other subject. In fact, type study is not a new thing just discovered; it is a very natural thing and has been employed deliberately many years. It is only recently that we have awakened to its full significance, and have begun to inquire into its real merits and to study the laws that determine its use.

There is one other consideration that ought to be noticed. Type study presupposes that an individual is the center of correlation for all the characters that pertain to it. Now suppose that we had all the observed characters of one type written in a vertical column under the name of the type. Beside it we have the name of another individual or type with all of its characters written under its name. Similarly suppose that we have the observed characters of several or many types written under their respective heads. Now shall we study our tables vertically or horizontally? Shall we make the type individual the center of correlation or shall one character expressed in the table the basis of our study? Shall we study how the bumblebee lives and moves and has its being, what organs it works with and what kind of a creature it is, or shall we study how animals defend themselves and notice thebumble bee's sting as a defensive organ? The latter practice is directly opposed to type study. The advantages of type study are so pronounced that I have no hesitation in saying that an individual ought to be made the basis of study, but in consequence of the natural disposition of people to run after strange gods I believe that many people overlook its advantages and try to make an abstract principle the center of study. I grant you that these general principles must be known, but they become known so easily and with such great educational benefit when several types are studied and compared that it seems to me a serious matter to abandon type study and make slight generalizations already worked out, the basis of study. Such things are very well in cheap magazines, newspaper science and popular lectures, but they can never constitute the core of a scientific education.

The earliest form of botany that obtained a recognized place in the secondary curriculum was plant analysis, epigrammatically characterized by an eminent botanist as having no more relation to botany than a collection of postage stamps has to geography. It was succeeded by a kind of cross section botany, which is still the bogie man of epigrammatic critics. Then we had a severe attack of root pressure botany, to be succeeded in turn by some plant relation botany and some plant society botany. A simple calculation will show that about every five years, a new modification of the subject is proposed and urged with all the fiery enthusiasm of an educational agitation. And all the time, the processes of learning have been constant, child nature has been the same, and psychological laws as immutable as gravitation. When shall we cease to look to subjects, and search in psychology for the basis of our educational processes. I believe I have shown that type study as properly understood conforms closely to the psychological processes involved in learning, and may safely be recommended as a pedagogical basis for the study of botany and geology.

It may be urged that type study fails to evoke interest and some other form of botany does. This is a good example of the suppressed minor premise. Any subject and any device in teaching will evoke interest if employed in the proper way. Interest resides not in the subject of instruction but depends upon the perception of relations between the thing taught and the pupil. Hence it cannot be used as a criterion of the value of the subject, but rather as a test of the effectiveness of the teacher. The first question the child asks is, "What is it?" It is an eminently proper question and demands an answer. When the thing studied has been labeled, the student has a power over it impossible to one who is not so taught. To know a thing is to know its relations. A thing really is the sum of all its relations. All subsequent study is merely an extension of a knowledge of relations the thing manifests. So the final question of the philosopher is the first question of the child, and the difference is represented by the number of relations in which philosopher's knowledge exceeds the childs'. So Tennyson expresses the profoundest truth when he says:

Flower in the crannied wall
I pick you out of the crannies;
  I hold you in my hand.
Little flower, if I could understand
  What you are, root and all
  And all in all,
I should know what God is and what man is.

THE CLAIMS OF NATURAL HISTORY IN BIOLOGICAL COURSES OF SECONDARY SCHOOLS.

W. P. Holt.

The frequent asking of the question, "What phases of biological sciences should be emphasized in secondary schools," suggests not only considerable latitude of choice in such subjects, but a possible change for the better in the nature of the work presented, or perchance an improvement in the manner of presentation.

The view of this paper is purely that of the secondary school, although in a way applicable to normals—for it is certainly of the geatest importance that our future secondary school teachers should have the right attitude—whatever it may be—in regard to what should be taught and how.

What biology shall be taught even in secondary schools must vary to some extent since such courses (Botany and Physiology especially) are given anywhere from the freshman into the senior year, depending upon the one responsible for the curriculum—who in the great majority of cases has, himself, a very limited knowledge of the sciences.

The time may come when some natural sequence and order will be generally recognized in the science courses of secondary schools; but such rational good sense in planning our courses of study is certainly a *long way off at present.*

But in whatever years, by mere chance or otherwise, the botany or zoology may be offered, is there not a common end to be sought? I hope there is no one here who would urge that this end for biological courses—or any others—is merely preparation for college. We all believe college training is well for a large number who complete the secondary school courses; but to attempt to shape, in any subject, the courses of all students in order to satisfy the college entrance requirements for the 2% to 3%, who go to college is quite as absurd as it is unjust. The purpose of every secondary school course in biology should be to train the student for broader, more intelligent, more valuable living, regardless of whether he is going to college or not. This is not an attempt to rail at the present college entrance requirements, but merely to establish our view point as to what should be the end sought in the work that we, as biology teachers, are attempting to do.

I believe that if a composite statement of our creeds and opinions on this point were made it would be something as follows:—

The purpose of secondary school courses in Botany and Zoology *should be* to give to the pupil a deeper and more intelligent interest in the plant and animal life of his region, to train him to keener observation and more thoughtful inquiry, and to give as thorough a working knowledge of these subjects as is possible in the time given.

Believing that the more thoughtful and more earnest teachers of Botany and Zoology are working for such an end, the main point of consideration becomes—how can we best secure this end? And it is here that I wish to present the claims of rational Natural History. By Natural History I mean not merely learning to recognize animals and plants in the field, but an intelligent, thoughtful study of same from the *life* side, rather than from the

dead (or dissection) side, or again, the study of animal and plant life directly from Nature, rather than the mere study about same. This includes not only the study of habitats and habits, but of life relations and even economic values: and furnishes incidentally a training in keen, discriminating observation, which will enable a good student to recognize points of similarity and difference, and at the same time gives a practical knowledge of many of the life forms of the region. Modern Natural History, in brief, includes the older Natural History, enriched by modern Ecology.

All Natural Science is so fascinating and so enriching that it ought not to be difficult for a well-trained teacher to interest intelligent pupils in that part of the nature world in which they live; and I believe this is easily done *if* the teacher himself has a love for the work, and *if* the right method of procedure is used.

The great masters of botany and zoology have been eminently successful in not merely interesting, but moreover enthusing their students with a love for such study; and wherever a lack of interest in these subjects obtains—if such may be the case—the trouble certainly *lies with the teacher* or the manner of procedure, or *kind of work* attempted, for the biological subjects *themselves* ought to be far more interesting today than ever before.

If the biological work in secondary schools is thoroughly effective it should lay the foundations for a deep interest and keen delight in biological study which shall only begin—not end—when such courses are completed. To accomplish this it is evident that the student must be trained in phases of the work he can carry on, or at least make use of, in later years—something that will put him in closer touch with his surroundings, and will afford keen delight in the travel, observations and leisure study of life after his school days are over.

Let us briefly consider *what* phases of biological work will give the *best preparation* for this end. How many students, after leaving school, will carry on the study of types with a compound microscope? Probably not more than two or three of our students out of a thousand will ever own a compound microscope; and whether these two or three would use the microscopes in studying types or not is doubtful.

How many students have you ever known who were so fond of dissecting snakes and worms, or even cats, that they would have the *least* desire, after leaving school, to carry on such work, making laborious careful drawings of muscles, nerves, or skeleton parts.

There may be some of this class but I have yet to meet them!

We are doubtless all familiar with Geo. Ade's tale about the big boy in the little red school house who "jumped the traces when he had to sit down and count the petals (as Mr. Ade incorrectly expresses it) on an ox-eye daisy." Of course, Mr. Ade is fond of *talking*—often without saying much—but that is his way of getting the coin, which means so much to him. Yet there is a grain of truth in this bushel of chaff after all. If a boy has any life and energy I shouldn't blame him for rebelling if he is *long* inflicted with dry, dead dissection work in either botany or zoology. A very limited amount of dissection work is doubtless of value in secondary schools—and as a college elective for a certain class it is without doubt important—but a high school course in biology where the work is largely done through the study of dead specimens is quite as much out of place for the average young pupil as a course in Paleontology would be. Both deal with dead forms, and one is quite as interesting, as inspiring, and as helpful as the other. And in some

schools where the interest is about as dead as the specimens they study, the reason is, I believe, very apparent.

On the other hand, we all know that an interest in the *live*—or Natural History—side of animal and plant life *does go* with many of our best students after their secondary school days are over; and the number of lay naturalists among the ranks of business and professional men, most fortunately, seems to be annually increasing. The number of such lay naturalists in England is remarkably large, and some excellent contributions to science are made through them. It is highly desirable that the same condition may in time obtain in our own country; and one of the best ways to hasten this time is to bring our biology students in closer touch with the Natural History of their environments, and to give them *practical* training in lines that can be made use of *in later life* rather than spending so much of the time on things that we know they will *never* use or *care* to use, or that would be of little value if they were used.

But fortunately the study of life relations, life functions, habits, life histories, and even the broader economic side is coming to occupy a larger and larger place in the biological courses in our more progressive high schools. In Botany, some of our greatest American leaders are urging that *more time* be spent in high school botany on the ecological, or broader Natural History side, and less on the dissection and morphological side. And should not this be equally true of high school—not college—zoology? More time, in truth, on the *live side* and less on the *dead* side of these subjects.

There is not much doubt that the dissection work, and the continued work with compound microscope, once planned and set in motion, is much easier to carry on from the teacher's standpoint; and there is even less doubt that such work is of far less interest—*certainly* of far less value—from the student's standpoint.

It is a hard confession to make, yet one that I honestly believe to be true, that *one* reason why some teachers of Botany and Zoology do not dwell more on the live, out-of-door side of their subjects is partly because the well beaten path of the indoor laboratory has come to offer to them a "line of least resistance," and partly because they fear to face many of the problems of the field—the latter in large part because they themselves have spent so little time in the field, and hence know so little of the flora and the fauna of their regions.

If we accept as a part of our biological creed that it is our duty to "interest the pupils more deeply and intelligently in the biota of their regions," how can we hope to accomplish this unless we ourselves spend *much* time in the field and have a good working knowledge of our regions? But how many biology teachers really *do* spend *much* time in the field or have a very comprehensive knowledge of the Natural History of their regions? How then can we expect to get the best results in teaching Natural History until teachers come to study their own regions, and get much of their teaching knowledge from Nature rather than from books.

A mere working acquaintance of our floras and faunas is by no means everything, but is by all means *something*—and something decidedly *worth while* for any teacher who expects to do any kind of field work. How much a teacher lowers himself in the estimation of his students if he is unable to recognize some of the most common forms in the field—possibly some forms that even a part of the class may know. Nor is this ignorance of forms in the field confined to secondary school teachers; you know college instructors and professors where this is true, and so do I.

With all the excellent field helps of recent years there is even less excuse

today than ever before for such ignorance—especially on the part of the teachers of subject that do—or should—include field work.

The work of the *indoor* laboratory, valuable as it may be, can in no way take the place of the great *out-door* laboratory, although work in the former may be done to supplement the latter in a most helpful way. "One of the most valuable attainments into which we can lead our students is the ability and desire to interpret the phenomena about them." Natural History is the gateway to the interpretation of these local biological phenomena; and in its study afield the student should see the "eternal *why*" attached wherever he looks quite as keenly and as certainly—and with even greater enthusiasm—than he sees even the ob'ects themselves.

Some of these "whys" may never be answered, others are to be hung up for present and future consideration, while some simpler matters may be answered by the student at the time. Since Natural History is in no way an isolated part of Science, it naturally calls into play all other subjects and lines of investigation that may be helpful in elucidating its problems. The compound microscope, and even a limited amount of simple dissection may be helpfully introduced to throw light on many of the problems which the study of Natural History raises.

One of the great values of the Natural History method of attack is that it stimulates the *best kind* of observation—the observation of animals and plants in their *natural surroundings*— and along with this should stimulate the spirit of investigation thru the numerous "whys" everywhere tacked on.

To the high school freshman who has raised the question *why* out of three cottonwoods in a certain yard two annually produce a crop of "cotton" and one never does, the later knowledge of dioecious floral arrangement of essential organs, comes with a very different meaning than to the pupil who has merely read a statement about same in his text-book—or likewise with the lad who wonders why woodpeckers have stiff, pointed tail feathers, and then watches some woodpeckers at work on the trunk of a tree.

The number of simple, and more difficult, natural history problems that a younger student may work on is limited only by his ability to see and think, and the resourcefulness of the teacher; and is it not here that the university trained teacher can show his real worth in suggesting *suitable* problems for his students, as well as suggesting the best methods of attack.

We hear more or less about the indoor laboratory exercises developing the so-called "laboratory babies." In this there is much truth—in secondary schools, and in colleges as well. This is partly because the printed sheet of laboratory directions tells the student everything he is expected to see—or to do; not much opportunity for original observation and thinking here. On the other hand, if the student can be made more interested in the Natural History of his region he may get not only a *vast amount* of *practical* knowledge of plants and animals as they live, but in attempting to answer the questions that Nature everywhere raises he is learning to do something of great value for himself—for *what is* the work of the biological investigator but attempting to answer the questions, more or less advanced, that Nature asks.

The clamor of the modern Croesus—be he Hebrew or narrow-minded business man—for an education that will turn everything into money is not to be considered by serious-minded people. The result of such an education would be about as fatal to culture and sound living as was the gold-converting power of Croesus of old. Yet serious-minded men and women have a right to demand a practical training that will be of value in later life.

If our biological courses are devoted largely to type studies or dissection

work, to the exclusion of the more vigorous study of Natural History, I fear that much would be lost to the student that would be of value to him after preparatory school days are over.

If there is any business or walk of life where keen observation and the interpretation of phenomena and situations about one are not of very *great* importance, I fail to know where it is. Moreover, if there are any phases of Biology that can better develop these attainments in students than a suitable, vigorous presentation of Natural History I certainly fail to know what it is.

So much for the desirability of the approach to Botany and Zoology thru the gateway of modern Natural History. Now a brief summary of some definite ways to create a deeper interest in the Natural History side.

The class field trip is one of the first ways to suggest itself.

This does not refer to turning a class loose to browse unrestrained or undirected in the field. Nor to the "sheep and shepherd" plan where the teacher leads and the pupils follow—*somewhere* behind, or where the one in charge occasionally rallies the pupils about him and attempts to talk when the others are not—or more frequently when they are. Such trips avail little—more often, in fact, belittle the subject.

If each pupil works independently with his *outline guide* of questions and problems he is expected to work out—this outline being given out on the day before, together with a brief introductory statement as to the purpose of the trip—and if all understand, moreover, that such an out-of-door exercise is a very important part of the course and counts accordingly, some *definite* work in the field can be depended on. In the "round-up" the next recitation period the various points of interest are discussed and results compared; and it is then easy to tell what the different pupils have actually accomplished. The concluding part is the final "write-up," which is then handed in as a regular exercise. Such trips afield, if rightly conducted, not only mean much to the student but offer some of the choicest opportunities to the active teacher to come in helpful contact with his student friends.

But class field trips, helpful as they may be, are *only one* of several ways to interest and train the pupil in the live side of the subject. Individual trips afield are stimulated in no small degree by the keeping of nature calendars on which are credited to the pupils making same the earliest observations (and date) of flowers in botany—or of birds, insects, or other animals in zoology. The ambitious pupil is anxious to get as many "first records" to his credit as possible, and hence is naturally led to spend *more* time in the field than he would otherwise do. Much, moreover, can be taught from the material thus brought in and the questions asked. From a trial of these nature calendars for four years I am more and more convinced of their value if carefully conducted. An exchange of lists with other schools—especially those to the north or south, often prove very instructive and creates a good-natured school rivalry which stimulates even greater efforts in the field. To eliminate errors so far as possible, the keeping of such records needs to be under the careful supervision of the teacher in charge.

A local collection of weeds, grasses, butterflies, beetles or other forms can be made very helpful, if encouraged and directed by a teacher who himself has made a careful study of the biota of the region. Such a Natural History collection, if properly encouraged and cared for, may become of considerable local value.

Local field problems, suited to the ability of the various pupils, may be

assigned, with good results, as *individual* problems; but to do this successfully the teacher must know his region thoroughly.

Next to the study of the things themselves in the field comes the "indoor field work," based upon stereographs, the stereopticon, and the best obtainable photographs and pictures. Excellent work may be done with all of these; and it is especially fortunate if there are in such collections a large number of *local* subjects. Short "indoor trips" with these can be taken where the material to be studied out of doors is not sufficient to warrant the time for a regular trip in the field.

Occasional written or oral, reports upon assigned topics, based on the best available library references, can be made extremely helpful by a live teacher, not only in imparting useful information, but in stimulating interest and thought as well.

A study of the local trees and shrubs in Botany is always interesting and helpful, and will not only do a great deal to teach pupils to observe, but offers one of the best ways to stimulate an interest in the local flora which will not end with high school days.

The study of birds afield by the pupils is quite as effective, in its way, in the zoology course. Although a teacher of Botany, I quite agree with Prof. Hankinson, of the Charleston, Ill., Normal who says: "I have never yet known a person to give up bird study when he had begun it with any degree of earnestness, and when conditions were favorable for its pursuance." That it is not difficult to interest high school students in bird study I know from my two large volunteer classes, where 70-80 are enrolled for the study of local birds, for which no school credit whatever is given. The increasing attendance and the interest shown have both been very gratifying.

A trip afield to study either birds or trees can scarcely be made without learning much of interest and value in addition to the particular object of observation sought.

Further, I do not believe that any boy or girl can become acquainted with the great out-of-door Nature world without receiving a refining influence as well as a strong uplift morally. Many more boys would, I believe, go thru school and *really do something* if they could be interested in the out-of-door study of birds and plants before they reach the hang-around-the-corner period.

What a world-wide difference, for younger boys, between the influence of bird songs and voices of the woods, and the smutty prattle of the street corner—to say nothing of the *physical value* of the tramps afield. If we, as earnest teachers, are interested in our boys and can help them by interesting them in Natural History, is it not then most emphatically *worth while* to emphasize the Natural History side of our subjects?

In conclusion, I wish to urge again the belief that the main purpose of the secondary school courses in botany and zoology should be to give the student a deeper and more intelligent interest in the biota of his region, and a greater desire and ability to interpret the natural phenomena of same; and that this end is secured *most* effectively thru the gateway of *modern* Natural History. That the student thus finds a keener delight in his introductory biological studies; and not only secures *much valuable training* and useful knowledge for later years, but is also getting something that, in many cases, he will find much pleasure in pursuing as a recreation or avocation, long after his secondary school days are over.

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NOTE ON TWO NEW INSECTICIDAL AGENTS.

R. H. Pettit.

The following preliminary note is offered for the sole purpose of placing on record two new and successful remedies for the control of insect pests. The first of these is a new remedy for bed-bugs; the old remedies, such as corrosive sublimate, turpentine, gasoline, Pyrethrum, fumigation with sulphur and all the rest, are efficient enough if used with enough thoroughness, but each one has some drawback likely to interfere with its continued use. Either it is a deadly poison or explosive, or else the odor is disagreeable, or in the case of sulphur, is likely to damage metal mork and wall-paper. There seemed to be a demand for a non-poisonous or mildly poisonous agent that could be used in sleeping-rooms without danger or serious inconvenience. The following scheme was hit upon and has proved very successful.

Alcohol is drawn through pyrethrum in a funnel until the powder is well washed and a large part of the resinous principle extracted. To do this, the powder is placed in a large funnel with filter-plate and a layer of cotton wool at the bottom. An aspirator is attached and the alcohol is at first slowly and later rapidly sucked through six or eight times, during which operation it becomes highly colored. To this liquid as a basis, are added several oils to give permanence to the application. Both alcohol and pyrethrum evaporate so quickly that it was thought best to carry in some heavier volatile oils whose effects would last several days or even weeks. The formula when completed stands as follows:

To the extract made by washing 400 grams of Pyrethrum with 2,000 cc. of strong alcohol, are added—
50 grams gum camphor
150 cc. cedar-wood oil
25 grams oil citronella
25 grams oil lavender

The application is best made with a large sized atomizer, one holding a pint or more and working with a piston instead of a rubber bulb, such an atomizer as is put out by the Corkins Chemical Co. for use with their insecticide. We have also used a potato-bug sprayer by plugging one of the outlets. To obtain the best results, repeat the treatment after about two weeks. We have tried this mixture repeatedly and with uniformly gratifying results. Usually one application, if thoroughly made, put a period to the complaints, about eight or ten ounces being required in an average sleeping-room. The odor remains some little time in a room, but is not disagreeable to the average person.

The second insecticide is used against ants in houses. When the nests are to be found by tracing the lines of workers, it is easy to destroy the colonies by the use of carbon bisulphide, but the nests are not so easy to find at all times, and the use of bisulphide about buildings is always dangerous because of the poisonous and explosive nature of its fumes.

Some two years ago, Mr. Howard Kraus, a druggist of Lansing, told us of his success with tartar emetic, and suggested that we experiment to find out the most efficient way of using it. Mr. Kraus used a mixture of simple

syrup and tartar emetic exposed in a saucer where the ants could get at it. It is well known that rats will leave certain buildings where tartar emetic has been mixed with their food, the pain produced by the drug seeming to convey the idea that such a place is unhealthy as it no doubt is, and they leave. Ants, living in communities, as they do, seem to become suspicious and alarmed if any considerable portion of the family disappears or shows unusual symptoms. At any rate, they start to migrate and few if any ever get away, dying in numbers on the road.

In our experiments, we aimed to produce the most attractive ant food to be had, and, having noticed the avidity with which ants sip up the beer and sugar which is painted on trees when sugaring for moths, we decided on beer and sugar as our basis. Beer was therefore percolated through sugar until a thick syrup was obtained. This was done in the absence of heat, so that the syrup has remained liquid ever since. To twenty parts of this, one part by weight of tartar emetic was added and to the whole a few drops of acetic ether to give the vinous odor so attractive to many insects. We have tried this mixture several times, and always with success.

During the testing of both these remedies, we have been aided by Mr. E. J. Kraus, at the time Assistant in Entomology.

Michigan Agricultural College.

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A CASE OF POSSIBLE PARASITISM IN THE LEPIDOPTERA.

R. H. PETTIT.

On Aug. 19, 1905, several tomato-worms, *Phlegatontius sexta*, were placed in a cage for the purpose of rearing the adults. On the following day, these larvae buried themselves in the soil of the cage, which was placed in the window insectary to remain until the following summer.

On Sept. 10, 1906, there were seen, flying about in the cage, a number of small tiniid moths, their pupa skins projecting from the surface of the soil where were concealed the dirt covered cocoons from which they came. These cocoons were fastened together loosely with silk, which also was spun out into the soil for some little distance. The pupal cases of the tobacco-worms, were found on examination, to be empty and dried up. Several cocoons were found attached to the pupal skins.

This rearing of a tiniid moth from the pupa of a much larger moth was sufficiently astonishing, though of course we could not feel sure that the larvae or eggs af the tiniids were not in the soil to begin with, and that they had not developed at the expense of animal matter already there. It was, therefore, decided to repeat the experiment under more exact conditions, and to this end a cage was prepared by Mr. E. J. Kraus, Assistant in charge of breeding experiments. A good sized flower-pot was filled with soil in the usual way, and a glass cylinder was set over it and covered with swiss muslin in the usual way, so as to exclude everything from the outside. A pot containing the soil was then taken out and steamed for several hours, thoroughly cooked with dry steam, the cylinder was then replaced and when everything had cooled off sufficiently, a fresh lot of tobacco-worm pupae were introduced. This was done on Apr. 25, 1907, the pupae having been obtained during the plowing of an old tobacco field. Seven pupae were secured and placed in the sterile cages, and on Aug. 1907, two more tiniid moths appeared. On the 18th of July, one adult tobacco moth was obtained.

A determination by Mr. Busck, of the Bureau of Entomology, places the creature as a well-known species, *Tinia pellionella* or the common clothes-moth. Now the clothes-moth feeds on dried animal matter, loving woolen goods best of all, and it is of course possible that it may have been feeding on dead pupae. We debated the question of dissecting some of the tobacco worm pupae, and of looking for foreign organisms, but decided not to because of lack of material and because the larvae of the Tinis would have been very small at that time.

In any case, this is a new and hitherto unknown habit in an old and well-known species. It shows how easily and naturally parasitic habits might be developed, the tiniid gradually working over from dead to diseased and finally to living hosts. There is one intance of true parasitism known in the order Lepidoptera, that of *Euclemsia bassettella* which works inside one of the oak coccids of the genus Kermes. The life-history of this species was discussed at a previous meeting of this society.

We hope to secure enough larvae and pupae this fall to be able to spare a number for dissection, even if we have to grow a few plants for the purpose.

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AN ECOLOGICAL STUDY OF THE BIRDS OF THE YPSILANTI BAYOU.

MAX MINOR PEET.

The observations included in this paper cover a period of six years and were made entirely by the writer. The area worked consists of about sixty acres, known as "the bayou" lying to the west and southwest of the Ypsilanti Highland Cemetery. This area includes a wide variety of conditions, embracing as it does, the cemetery proper, with its steep slopes, a large bayou with a stretch of flood-plain, and the river. Observations were made throughout the entire year and under all conditions of weather. In this small territory all the environments which are usually spread over many square miles are brought together and are easily accessible. For this reason the place is particularly rich in bird and plant life. In fact, the complete list includes all the common and most of the rare birds to be found in Washtenaw County.

The bayou alone offers exceptional opportunities for study from an ecological standpoint, because of the variety of conditions and the fact that it is practically free from changes due to man. It is further favorable in that it lies directly in a line of migration, the Huron River valley being well-known as a path for these birds.

The results h re presented are the outcome of an attempt to compile a list of the birds found at the bayou together with the habitat relations of each species. Food, nesting sites and protection are the chief factors to be considered in such an investigation.

It is an established fact that the flora of a region is dependant upon the environmental conditions. That birds of a limited area are dependant on the plant life of that particular area I will attempt to show in the body of the paper. But since the plant life is dependant on the physiography of the region, which is the "resultant of the geological formations and the agencies at work modifying them," it must change as the physiography changes. Therefore the bird life being dependant on the vegetation will also experience a similar change. The interrelations existing between the birds and plants and the environmental conditions are more clearly seen by considering the physiography in its dynamic or unstable condition. A knowledge of the changing conditions is therefore necessary to explain the distribution of the bird life in this region. In view of this fact the area was divided up into stations each representing a definite habitat. The change taking place in each station with the seasons necessitates dealing with each period separately. Each habitat will be divided into four seasonal divisions beginning with spring. The divisions are based upon the migration records of the commoner species, and are as follows: March 1st to June 1st, spring; June 1st to Aug. 15th, summer; Aug. 15th to Nov. 1st, fall; Nov. 1st to March 1st, winter. The food of the principal species was determined both by stomach examinations and observations in the field. Observations on the relative abundance of available food were also made, and will be considered with the food habits. The nomenclature of the A. O. U. is used and Britton and Brown's botany for the plant life.

I wish to thank Dr. Hinsdale of Ann Arbor for his kind offer to bird s udents

of Coues' Key to N. Am. Birds as an incentive to the writing of a paper on an ecological subject. I also wish to thank Dr. Chas. C. Adams for his many valuable suggestions and advice in the prepartion of this paper.

GENERAL DESCRIPTION OF THE REGION.

The area studied, as before stated, consists of about 60 acres situated at the bend in the river lying west and southwest of the Highland Cemetery. From the cemetery, situated about 100 feet above the level of the river, an excellent view of the bayou may be had (Fig. 1). The river at this point is about 15 feet deep and bordered by mud flats for the most part heavily overgrown with water plants. Extending back from the river a distance of about 160 yards lies a low strip of land overgrown with flags and sedges in the more moist portions, and forming a meadow on the drier ground. Bordering the river for about half the distance is a thick growth of brush edged by good sized willows. Between this and the swampy meadow lies a strip of shallow open water. Extending back to the bluffs lies another belt of scrubby willows and low brush. As the bluffs rise at an angle of about 35 degrees to a height of 70 feet above the meadow they offer a decided contrast in environment to the swamp below. The geography of the region is almost entirely glacial, the cemetery bluff being a portion of an old sand bar left by Lake Maumee, the first of the series of large glacial lakes formed in this region on the retreat of the ice sheet. The weathering of this bluff is very rapid in times of heavy rain and much of the flat meadow land at its base has been formed from it.

The Soils: "The distribution of surface soils is important because of the relations existing between soil types and plant societies." The flood plain is composed fundamentally of compact till with areas of peaty earth about the center and between the ponds and bluffs. An outwash of sand is found at the northwest and southeast. A long ridge of mineral soil extends from the northwest along the stream to the marsh at the bayou. Humus is found everywhere except on the washed slopes of the bluffs. At the east a strip of sand borders the bluff, in which seepage springs frequently occur.

Soil Water: Areas of extreme dryness may be found along the brink of the steeper bluffs, the moisture steadily increasing toward the base of the slope. Around the springs at the base of the bluff it is often so moist that one will sink up to the ankles in the soft soil. The water of the bayou is quite cool from the constant percolation of spring water from the bluffs. The ridges are usually moist although free from all surface water. In order that a detailed study may be made of the relations existing between birds and their environments, the region is divided into four stations. Station I., Swamp; Station II., Arboreal Willows; Station III., forest; Station IV., dry open meadows.

GENERAL DESCRIPTION OF SWAMP, STA. I.

The general character of the swamp is open with scattered shrubby willows. Under this head the open marsh, the damp meadow, and the brushy low land extending to the base of the bluffs, are considered. The swamp covers about twenty acres of which the marsh (the area overgrown with rushes, flags, etc.) constitutes about one-half. The water usually covers the lower portion of the marsh from a few inches to two feet in depth, varying with the location and rainfall. Quantities of pondweed grow along the shallow border of the river and mingled with these and extending to the edge of the rushes we find the white water lily (*Castalia adorata*); spreading back into

the shallow muddy bays the yellow pond lily (*Nymphaea advena*) forms thick beds. The current here is scarcely perceptible. Surrounding the beds of lilies the deep water sedge (*Carex stricta*) forms tufts of great compactness and strength. Beds of water smartweed are mixed with the yellow pond lilies and other plants, forming dense mats of floating vegetation which will support the weight of a person. Further back from these are extensive beds of sweet flag. Scattered about but principally near the center of the bayou occur large patches of cattail. Skirting the bluffs and extending well out toward the river on the southwest side is a strip of moist ground which is overgrown with a variety of vegetation. Mixed sedges constitute the major portion, but long grasses, low weeds and some taller varieties such as the Golden Rod and Iron weed abound. During the early spring this region is partially covered with water, but it soon recedes and leaves only shallow, grassy pools which are seldom dry because of the spring water which percolates through the soil. Much of this land is rough, hummocks of earth being scattered about over it. These hummocks are usually overgrown with tussocks of sedge or long grass and furnish excellent nesting sites for many of our ground birds. The soil beneath is mostly humus and supports a luxuriant growth of vegetation.

The location of brushy low land can best be seen on the map. It is composed of several varieties of shrubby willows which grow close together forming dense thickets. Many bushes are scattered over the neighboring low land and are preferred by the birds to the denser clumps.

A damp meadow lies between the flags and the bluffs, the soil of which is largely composed of earth washed down from the surrounding bluffs. This is mixed with the humus formed by decaying plants and with the silt deposited by the river in times of flood. The vegetation consists almost entirely of grasses which seldom grow more than a few inches high. For the most part, especially the area covered with low hummocks, the grass simply forms a flat mat and serves only as a feeding ground for the birds.

CONDITIONS IN SPRING.

With the opening of spring, the first of March, the swamp presents a dreary appearance. Ice and snow cover most of the surface and the only food for the birds is to be found in the few sheltered spots under the bushes, on the exposed portions where the snow has melted off, and the weed seeds which still cling to upright stems or have fallen off on the snow crust. With the melting of the snow later in the month the river rises considerably, often flooding the meadow nearly to the bluffs. As the season advances the water again retreats, leaving much rubbish scattered over the land. In this waste material the birds find considerable food. Soon after the snow has entirely disappeared, the flags and other marsh plants begin to send up green shoots. The water then stands about its normal height, covering all the lower reed grown portion from three to twelve inches deep. By the first of June everything is at its prime, the water lilies and flags are in blossom, and food, both insect and vegetable, is plentiful.

CHARACTERISTIC SPRING BIRDS.

Red-winged Blackbird. (Agelaius phoeniceus phoeniceus.) The most abundant resident of the swamp is the Red-winged Blackbird. Arriving in large flocks about the middle of March, it soon outnumbers all the other birds of the region. From early morning till twilight it may be seen hovering

over the dead reeds or hunting industriously in the decaying vegetable matter for food. At first, seeds constitute the principal article, although refuse and a few insects are sometimes eaten. The red-wings, like many other members of the marsh family are eminently gregarious. Upon arriving in the spring, the courting begins at once, although nest building must be delayed for several weeks, as no nests are built until the cattails are nearly grown. The females spend much of their time walking about among the dead, broken down herbage, probably seeking food, but the males strut about on the limbs of the near-by trees, their feathers ruffled up and body swelled out.

During the spring, the principal food, as determined by thirty stomach examinations, is grubmorms, caterpillars and other larvæ. Grasshoppers, crickets and earthworms are relished and a stomach is seldom examined which does not contain at least one of these forms. As soon as the weather becomes warm enough for these insects to appear, the red-wings may be seen walking about the swampy meadow searching diligently for them. Snails when found are greedily eaten as are also the crayfish and dead animal matter found along the river bank. Beetles of several kinds are eaten, but not extensively. At this time of the year few seeds remain, therefore constituting a small part of the diet. It is worthy of note that during this period, the red-wings are seldom met with outside of the masrh and so must procure the bulk of their food in it. This becomes more significant when we consider that within a short distance are stubble fields thickly overgrown with weeds, while several nearby fields are under cultivation and would furnish many grubs as well as scattered corn and wheat. None of the stomachs examined contained any kind of grain.

Although not shy, they will not allow a close approach and rise up in a clamoring, motley flock, which wheels about to alight in some nearby tree or further out on the marsh. During the time elapsing between their arrival from the south and nesting, the red-wings may usually be found scattered over the entire swamp, but with the coming of the breeding season they collect in the clumps of cattails, where in a short time the nests will be built. The females now seem more retiring than ever, seldom flying far or even venturing out from the sheltering cattails except to feed. The males, however, keep up their singing and display. The first nests are uually completed by the middle of May, the earliest record for complete sets being May 9, 1902. The material for the nest is gathered in the immediate vicinity, being composed of dead flags, pieces of cattails, reeds, and sedges, and lined with fine dry grasses. As they are usually fastened to several stems they are often pensile. A few are found placed in tussocks of sedge. The eggs vary in number from three to five and show a surprising variation in color, markings, and size.

When the nesting grounds are entered, a great commotion occurs. All the red-wings gather to drive the intruder away, but though reinforced by large numbers from the neighboring breeding sites, they do not dare approach the stranger, but with the gathering throng keep up a clamour sufficient to alarm every bird within half a mile. If the young are in the nests the parents grow bolder and circle above the heads of the trespasser the cries of distress from the nestlings sometimes drawing them within a few feet. After the first brood is reared, another nest is started. Two or three broods are usually raised. With the hatching of the first set, the red-wings range over a greater territory seeking food, probably because of the greater strain put upon them now that four or five growing young have to be fed. But even at this time, a red-wing is seldom met with outside of the swamp, which clearly demon-

strates how plentiful the insect life must be, for the food of nestlings, according to Judd, consists of weed seeds, 1 per cent, and insects 99 per cent. The animal food found in the stomachs of 12 nestlings consisted of beetles, lepidoptera, spiders, and a few snails. The food of adults consists of nearly the same animal matter as that of the nestlings, but with a much larger per cent of seeds. By the first of June, numbers of immature blackbirds gather into flocks and may be seen wandering about in the marsh, feeding upon insects or picking up the refuse on the bank of the river. Many of our birds, while gregarious during the spring or fall, separate during the nesting period. The red-winged blackbirds however, associate with other members of their species throughout the year. Sometimes as many as a dozen nests are found within a space ten feet square. Storms seem to trouble these birds very little, for during the heaviest rains of spring they may be seen flying about.

Long-billed Marsh Wren. (Telmatodytes palustris palustris). Another characteristic bird of the open marsh is the Long-billed Marsh Wren. Though seldom seen because of its shyness the nests are very common, and its song may be heard throughout the day during the breeding season. These little birds remain concealed among the reeds and sedges and are only seen for a moment as they rise and fly a few feet to quickly settle out of sight again. The most successful observations were made by concealing myself in the vicinity of a nest and remaining quiet. Soon the birds seem to forget the presence of a stranger and go on with their household duties as before. By the time the wrens appear in the spring, the insect life is abundant, and nest building is soon undertaken and by the middle of May complete sets are found. The nest is usually built in a tussock of sedge, often the dense deep water sedge (*Carex stricta*). The foundation consists of a few damp stems of sedges, grass, etc., woven lightly but firmly about the central portions of the tussock. At the same time the walls and dome are commenced, so in the course of a few hours the shape and size of the entire nest may be seen although comparatively little material has been used. The damp material is gathered on the spot and used throughout except for the lining which consists of fine dry grasses. Interwoven with the dead grasses are leaves of the living sedge in which the nest is placed. So skillful is the nest hidden that it is sometimes impossible to locate it when right before one. The majority are built about two feet above standing water. Sometimes the nests are located at the very edge of the river, but the site usually chosen, is in the thick sedges a little distance from the bluff and separated from the open water by a thick bed of cattails. Here they are protected from winds from any direction, and the only enemies which play an important part are the cattle which usually graze on the nearby hillside, but come down into the marsh when flies become too troublesome. These animals tramp down the rushes and eat the tops. At least twenty nests were thus destroyed in one afternoon. The wrens have a curious habit of building several "fake" nests in the vicinity of the one occupied. This was often observed, as many as six nests, complete except the lining, have been found within a radius of five feet from the occupied one. The true nests are often placed close together, colonies of ten or twelve nests occupying a space not more than six feet square. Often when the nest is completed a tuft of the white cotton from the flowering sedges nearby is woven over the circular entrance. This is so general that I usually locate the opening by glancing over the nest for this conspicuous mark. By the middle of May, the sets are usually complete, but

this depends largely on the season. In the spring of 1904, which was an average one, the first nest containing eggs was found the 15th of May.

Their food as determined by examination of 9 stomachs, consists of caterpillars, ants, beetles, spiders, moths and many other small winged insects.

The song of these birds is beautiful, resembling somewhat the song of the house wren with its rippling, bubbling, gurgling notes. Chapman, speaking of their singing, says, "it is quite beyond their control; they seem filled to overflowing with an inexhaustible supply of music. Sometimes, like a mine of melody, it explodes within them and lifts them from the dark recesses of the flags up into the air above."

The marsh wrens are nervous little bodies constantly on the move, jerking their tails up over their backs, hopping from one stem to another, or rising on fluttering wings a few feet above the rushes.

They seldom venture far from the thick tussocks and are never met with outside of the marsh or within it except at this particular spot. This well represents how limited a bird may be in its habitats, when in the chosen environment it flourishes in large numbers. The question of protection must be the paramount object for remaining secluded in the dense sedges, because the same kind of food can be obtained in larger quantities in the more open portions of the swamp.

I have been fortunate enough to see the marsh wrens when they returned from the south in spring. It was a little after daybreak when they appeared along the river bank. Instead of flying over the more open bushy spots to the reeds beyond, they sought cover as soon as possible and covered the remaining distance near the ground, running under logs and brush as the house wren is wont to do. From this it can be inferred that protection is one of the principal factors involved at this time. It is noticeable that the nesting site appears to be chosen with regard to winds, as where the nest is built near the edge of the river, and consequently exposed to strong winds, it is built in the strongest, most compact tussocks present, while in the protected places, as between the clumps of willows and the bluff, the nests are placed near the top of tufts of slender marsh grass and reeds which offer little resistance to wind and are easily blown down in the exposed positions. Because of their short, broad wings, they are poor flyers and this probably accounts for their desire to seek protection as much as possible.

American Coot. Fulica americana Gmel. About the first of April a few Coots appear and spend most of the time feeding in the shallow pools among the water lilies and in the open river. More of these birds would probably remain if it were not for their resemblance to ducks which cause them to be shot at repeatedly. The nests are completed by the last of May. Several are found each year among the rushes and flags, sometimes near the river, but generally in the most inaccessible spots in the swamp. The nests are usually surrounded by water, and are never built where water is not standing. Composed of the dead stems and rubbish which are procured in the vicinity, they stand only a few inches above the water. The interior, or rather the surface of the nest, as it is very shallow, is often damp from the wet decaying material of which the foundation is composed. Dead reeds and flags, compose the bulk of the nest and are often heaped together from the material lying about it. For this reason the nest is difficult to locate. The habit of breaking down the flags surrounding the nest is often the only clew to its location. This appears to be a common trait of the Coots wherever a nest is located, as many places were found where the green shoots had been pulled up or broken down, forming a patch five or six feet in diameter. The pink

tender ends of the sweet flag which have been pulled up in this way are usually eaten.

The Coots are quite shy, and prefer to remain in the middle of the stream when any one is near. When approached closely they patter over the water, using their feet as much as their wings, but seldom go far, generally settling down on the water again or wheeling around to some quieter spot in the swamp.

Only three stomachs were examined and the food found consisted principally of insects, aquatic plants and small molluscs. The shallow pools and submerged portion of the bayou offer exceptional opportunities for feeding and one seldom visits this spot without seeing a pair of these birds floating on the stream, or chasing each other noisely about among the lily pads.

This habitat is well suited for these birds, as it furnishes an abundance of food, excellent nesting sites and good protection.

Yellow Warbler. Dendroica aestiva (Gmel.) These birds arrive about the first of May, the earliest date being April 28 (1902) and the latest, May 2 (1903). The birds are in full song on their arrival and soon commence nest building. The high willows along the river and the shrubby ones lying between these and the bluffs, are the favorite haunts before nesting. They seldom descend to the ground or even the high weeds. Neither do they rise into the tops of the high willows, but prefer the bushes. A position exposed to sunlight is usually chosen, both for nesting and when singing. In very few cases are nests built where the bush is not exposed, as in a dense thicket. They are generally constructed of plant fiber, grass, and plant down, all gathered within a few feet of the nest.

In ten stomachs which were examined, small flies, caterpillars, spiders, and a few small beetles were found. The young are fed the same insects as those eaten by the adult. Most of the food is obtained from the neighboring bushes, the flying insects being often taken on the wing after the manner of flycatchers.

Unless considerable disturbance is made, these warblers show little fear of man; this is possibly the result of their being so seldom molested in this habitat, as those which nest in the more accessible habitats at the bayou are quite shy.

Nests of the Yellow Warbler are seldom found which do not contain one or more eggs of the Cowbird. As a general rule the warblers either build a second story and thus bury the eggs completely, or else they weave a thick lining in the nest which partially covers the eggs and prevents their hatching. One nest was found composed of three stories all containing Cowbird eggs, and in the upper two, the eggs of the warbler. In all it contained six Cowbird and eight warbler eggs, five of the latter being in the upper story. This nest was just nine inches high and was built in the crotch formed by four slender branches springing from a central limb. While Cowbirds are quite common at the bayou, few of the nesting birds are as seriously troubled by them as are the Yellow Warblers. This is probably the result of the nest being placed in such an open exposed position where it is easily found by the female Cowbird. If the nest was hidden like the Song Sparrow's, or was built in the denser thickets, the Cowbird would be much less liable to find it. It is evident then, that while this particular habitat is the home of the warbler because it furnishes abundance of food, good nesting sites, and protection from the common enemies, it does not furnish protection from the Cowbird, and principally because the nesting sites are usually chosen in the most

exposed positions in the bush. The combination of swampy lowland and scattered bushes as found in this particular habitat proves to be the favorite home of these birds. In other habitats at the bayou each of these conditions exist separately, but only a few Yellow Warblers are found in them. It is evident, then, that those factors which tend to produce this combination of lowland and brush are the ones most favorable for the distribution of the Yellow Warbler.

Melospiza cinerea melodia (Wilson). Song Sparrow. This common sparrow arrives about the first of March. In mild winters like the last one (1905-6) a few remain here. In the spring before the plants have leaved out these sparrows are usually found sitting in the tops of dead bushes. At first the food is almost entirely weed seeds, but as soon as the insects appear it turns to them. One stomach collected in Mar. 7, 1906, contained several weed seeds, three caterpillars and remains of other insects. Twenty-seven stomachs examined between May 1st and July 1st contained a small amount of weed seeds and in a few cases remains of some kind of fruit. The major portion consisted of insects which were probably gathered entirely in this habitat, as the insects eaten were abundant here and field observations confirmed the supposition. Small beetles, slugs, two-winged insects, moths, snails, small larvae, and spiders were found in nearly all the stomachs examined. After the nesting has begun the birds resort less and less to the bushes, spending most of the time among the tussocks of long grass which cover the drier portions of the open lowland. The nests are usually built in one of these tussocks and are composed of dry grasses collected from the neighboring tufts. The foundation is laid on the top or hollowed outside of the hummock bearing the tuft.

That this is an ideal habitat for the Song Sparrow is evident for the following reasons: First, the food of the species as determined by Judd and as shown by the examination of specimens taken in this habitat is very plentiful. Second, the tussocks of tall thick grass offer excellent nesting sites, besides furnishing the material of which the nest is made. Third, the long grass offers ample protection not only for the nest, but for the bird as well. A large amount of dead grass remains from the previous year and so closely does the coloring of the Song Sparrow resemble this that it is quite safe from the searching eyes of any hawk which might pass over.

These birds are one of the most abundant species found at the bayou, and are found in every habitat, but only in small numbers, the swamp being the environment best suited to their needs.

Galeoscoptes carolinensis (Linn.). Catbird. This bird, like the Redwing is confined quite closely to the swamp land, but unlike the latter it inhabits the shrubby willows and other bushes. The Catbird arrives about the first of May and retires immediately into the thick, dark clumps of willow brush. The food consists of insects and fruits. Five stomachs were examined before the berry season commenced, and three after. The former contained several varieties of insects, such as moths, flies, small green larvae, and ants. One stomach contained the remains of many small beetles. The birds taken during the berry season had fed principally on strawberries, red raspberries, wild currants, and a few choke cherries. Only a few insects were found in these stomachs, larvae and small flies being the most numerous. All the fruits mentioned and several other varieties are common in the drier portions of the area worked, but do not occur to any extent in the swamp. This necessitates the bird leaving its habitat for these fruits. However, all the insects eaten are abundant in the swamp and

are usually procured there. The nests are built in the thickest bushes, generally four or five feet from the ground. The dead twigs, loose grape vine bark, and dead leaves found within a few feet of the nesting site, compose the bulk of the nest. Its lining consists of fibrous roots and grasses also picked up in the vicinity. The four eggs are usually laid by the last of May, and in warm springs young have been found before the first of June. No stomachs of nestlings were examined, but their food as determined by Judd consists of ants, beetles, caterpillars and other insects with only a little fruit. These insects can be easily procured near the nest and probably constitute the principal food of the nestlings here.

The thick clumps of willows which the Catbird chooses for its home offer excellent protection, and if a Catbird is disturbed in the open it immediately glides into the depths of one of these thickets where nothing more will be seen of it, its plaintive cries being the only indication that it has not entirely left us.

OTHER COMMON BIRDS.

Ardetta exilis (Gmel.). Least Bittern. Among the birds not common enough to be called the characteristic birds, but yet deserving special notice, the Least Bittern should be mentioned. They are unusually shy and are seldom seen although the nests are found repeatedly. The thick beds of sweet flag are the principal nesting sites, a few, however, have been found among the reeds and cattails. The foundation is built by bending down the flags and plaiting them together forming a platform from one to three feet above the water. Woven together on top of this is a mass of dead flags and rushes. The nest is quite shallow, one built among the rushes was simply a platform and stood only a foot above the water. No stomachs were taken, but the food must be procured entirely in the marsh as they are never met with in the other habitats.

Actitis macularia (Linn.). Spotted Sandpiper. This common sandpiper is found along the shore, on the mud flats in the swamp, and beneath the high willows where the ground is damp and there is no underbrush. In the early spring when the mud flats along the bayou are soft and covered with food left by the retreating water, numbers of these birds may be seen nearly any time of day running about picking up snails, insects, and other food.

As the season advances these mud flats dry up or become overgrown with various water plants, thus destroying the feeding grounds of the sandpipers and necessitating their migration to a more favorable habitat, the one chosen being the arboreal willows (Sta. II.). Under these large trees the ground is very damp with little or no underbrush and is nearly as open as the mudflats, the dense shade preventing evaporation and low vegetation.

No nests have been found, but it undoubtedly breeds here as the birds are found from early spring to fall and half fledged young have been seen accompanying the parents.

OTHER BIRDS.

The following are general observations on some of the remaining birds found in the swamp during the spring. A complete list of all birds seen in the habitat can be found at the end of this division. In the early spring large flocks of Bronzed Grackles come to the swamp, but only remain a few days and during this time stay principally in the arboreal willows (Sta. II.). In the dry, grassy spots a few Meadow Larks feed while Brown Thrashers sometimes join them there. Along the muddy margin of the bayou, Killdeer,

Solitary and Pectoral Sandpipers are found. The latter are migrating and only remain a few days. Several varieties of ducks stop here on their northward journey. The herons, except the Least Bittern, are only accidental although the Green Heron should nest here as all the conditions are present which determine its breeding in other parts of the valley. The Virginia and Sora Rails nest here in limited numbers. One nest of the latter was found June 15, 1904, containing eight eggs, and another June 17, 1904, with twelve eggs and one downy young. These nests were placed in the beds of sweet flag, one nest of the Virginia Rail was found among the cattails. A few Swamp Sparrows nest here with the Song Sparrow.

CONDITIONS IN SUMMER.

Under the head of general conditions the summer habit is quite fully described, for at this time all the sedges, water lilies, etc., spoken of are in full growth. Food of all kinds, especially insects, being very numerous. All the common species which birds are known to feed upon are easily obtained, which means much to the parent birds at this time of the year when the young are being hatched. Excellent protection is furnished by the thick sedges which grow to a height of two to three feet. The beds of sweet flag also furnish cover for several species not found among the sedges. Redwinged Blackbirds find the tall, thick masses of cattails the best place for nesting and refuge. Not much rain falls during the summer so the river sometimes drops so low that the larger portion of the marsh is left dry except for the moisture from below. This causes a premature dying of many plants, but does not seem to seriously affect the bird life. The maturing of fruits and seeds in other habitats causes some of the birds to extend their feeding ground, but does not affect their abundance in this habitat to any appreciable extent.

CHARACTERISTIC SUMMER BIRDS.

The characteristic summer birds are the same as those characteristic of this habitat in spring. Therefore, each of these birds will be taken up and the changes produced by the new conditions discussed.

Agelaius phoeniceus phoeniceus (Linn.). Red-winged Blackbird. These birds continue nesting through June, their feeding and other habits remaining essentially the same. With the closing of the nesting season the Redwings gather into flocks and wander about the swamp and into the neighboring habitats. Their food at this time consists of insects and a considerable quantity of weed seeds and a little grain. They generally return to the cattails at night, however, a few sometimes roost in the bushes and willows along the river.

Telmatodytes palustris (Wils.). Long-billed Marsh Wren. These birds remain in this habitat throughout the summer. The reeds and flags generally die during the dry season in August, but sufficient food and protection still remains, for the birds have never been seen in any other habitat at this season.

Fulica americana Gmel. American Coot. When the young of this bird are old enough to travel, the old and young gather into small flocks and constantly change their feeding grounds. One day they may be found at the bayou, another a considerable distance up the river. There does not seem to be any rule governing these wanderings and they are probably made with the object of securing or in pursuit of particular kinds of food.

No stomachs were obtained, but they probably would contain the same food as those taken in late spring.

Dendroica aestiva (Gmel.) Yellow Warbler. The Yellow Warbler continues nesting during June, and young hardly able to fly are sometimes seen late in July. These latter are probably from parents whose earlier nests were destroyed. No changes of note occur in the habitat of this species from June to the last of August. The Cowbirds previously mentioned in connection with this species, gather together, usually the males and females forming separate flocks.

Melospiza cinerea melodia (Wilson). Song Sparrow. The Song Sparrow nesting time over, wanders about the marsh and adjacent habitats in search of food. They are constantly passing to and fro from the bluffs to the swamp and back to the bluffs again. Many of the weed seeds are now ripe and constitute the principal food. It is for these seeds which grow more abundantly on the bluffs that the Song Sparrow leaves the swamp. It usually returns to the lowland to roost.

Galeoscoptes carolinensis (Linn.). Catbird. The food of this bird experiences a decided change with the coming of the berry season as previously stated under the spring heading. As the summer advances this change becomes greater and some stomachs have been taken which contained nothing but fruit. Very little fruit of any kind can be found in the swamp so the Catbirds leave this habitat and hunt for their favorite food along the bluffs and in the berry patches near the cemetery. A good many catbirds remain in the swamp, however, and as they are seen passing back and forth to the lowland it is probable that they simply go to these other habitats in quest of fruit.

OTHER COMMON BIRDS.

Ardetta exilis (Gmel.). Least Bittern. With the dying down of the sweet flags and rushes which takes place during July, the retreats of this bittern are destroyed. The cattails still remain standing although dead and in these the Least Bittern finds protection.

Actitis macularia (Linn.). Spotted Sandpiper. As summer advances these birds migrate to the damp heavily shaded spots found under the arboreal willows (Sta. II.). A few birds may usually be seen along the banks and sand bars of the river. Here, snails, beetles, and other insect food is gathered.

GENERAL OBSERVATIONS.

Some years the Northern Yellow-throat is common, other years only a few are seen. During the early part of summer these warblers may be found in the damp thickets, but as the season advances and these spots dry up they retreat into the bushes along the river where standing water is still present.

A few chickadees wander down into the swamp and now and then a Downy Woodpecker finds its way to the thickets. Late in June the Rose-breasted Grossbeak is found nesting among the dense, shrubby willows.

Conditions in Fall.

By the middle of August the vegetation characteristic of the swamp is nearly all dead and turned brown, but still stands, affording protection to the smaller birds. This part of the season is usually dry and much of the land covered with water during the spring or early summer is now dry ground.

The banks no longer offer the soft mud flats so alluring to the sandpipers.

Instead it is hard and baked or covered with vegetation which has sprung up during summer. The insect life is very abundant, myriads of the smaller winged insects constantly hovering over the grasses or lurking among them ready to swarm out at a slight disturbance. By the first of September, all the plants have seeded and now these are added to the bill of fare for the birds which still remain. Many seeds of plants not growing in the swamp itself are carried here by the winds or washed up on the bank by the river.

CHARACTERISTIC BIRDS.

Agelaius phoeniceus phoeniceus (Linn.). Red-winged Blackbird. During August and the first part of September the Redwings congregate in great flocks, troups of a hundred or more coming and going every day. These flocks are composed of males, females and young of the year, the latter of course greatly predominating. They are seldom seen feeding now and the stomachs examined contained a large per cent of grain which must have been gleaned outside of the bayou. They roost in the cattails and shrubby willows. Toward sunset, flock after flock of Redwings may be seen coming to these roosts. At this season the swamp simply furnishes a place for these birds to congregate and rest nights.

Zonotrichia albicollis (Gmel.). White-throated Sparrow. While this is only a migrant it occurs in sufficient numbers to be called one of the characteristic fall birds of the swamp. While it is found in other habitats to a certain extent, it occurs most abundantly in this one. It arrives about the middle of September and the last ones leave about the first of November. During this time it consumes immense quantities of weed seed and a few insects. The thickets of willow and the weed grown lowland are the places where it is most abundant. Here its brownish plumage harmonizes well with its surroundings. These sparrows are often seen scratching among the decaying leaves like a barnyard fowl.

OTHER OBSERVATIONS.

As the season advances and migrants grow more numerous a few straggling warblers are found in the bushes and small flocks of Golden-crowned Kinglets wander about among the shrubby willows. Slate-colored Juncoes are often met with in the drier spots, and late in the fall flocks of Tree Sparrows are seen almost daily. The weed seeds scattered about over the ground are the chief attraction for these latter birds. When disturbed, they take refuge in the thickets from which they seldom wander very far. During the first part of this season, that is, from Aug. 15th to Sept. 1st, the birds are moulting and move around very little, getting what food they need near at hand, and remaining for the most part concealed in the dense thickets. As the season advances, they stir around more and toward the end there are no birds which remain exclusively in this habitat as there are in spring and summer. The characteristic birds of the previous seasons have migrated by the end of September, and birds from the North are taking their place. The white-crowned Sparrow makes his appearance at this time, but not in sufficient numbers to attract much attention.

Conditions in Winter.

The winters as a rule are comparatively mild, some winters there is very little prolonged snow; and again other winters will see the earth covered

from December to March. Most of the season the thermometer rarely goes below zero. The swamp is protected by the wooded bluffs from all north winds, and so is one of the most sheltered places during this stormy period. When snow covers the ground, the only available food is the seeds which still cling to the dead stalks, but where the snow has melted away or in protected spots, as beneath the dead sedges, much food may still be found. Seeds and hibernating insects have been taken by the writer in these protected spots which shows what foods the birds can procure here. At this season all the stations are more or less alike as far as the environments influencing bird life are concerned, because the vegetation, which is the chief factor, is almost entirely lacking.

CHARACTERISTIC WINTER BIRDS.

Spizella monticola (Gmel.). Tree Sparrow. This Sparrow and the Junco are the most abundant birds found in the swamp during the winter. It arrives the last of October and remains until April. During this time it ranges over a considerable area, but is found in largest numbers in the swamp. The thickets here furnish it protection and the abundant weed seed plenty of food. Because of the similarity of conditions in the different habitats it could not be expected that this sparrow would confine itself to any particular spot, but the concealment from enemies furnished by the thickets, and the protection from the cold winds afforded by the surrounding bluffs makes this habitat the favorite one. The birds roam around in flocks of a dozen or more and are often seen in company with juncoes.

Junco hyemalis (Linn.). Slate-colored Junco. The common name for the junco in this part of the country is Snow Bird. It comes and goes about the same time as the Tree Sparrow, namely from October to April. These birds do not confine themselves to any particular locality, but occur in large numbers in the swamp. The food consists of weed seeds and the fruit of the sumac. Small flocks of these birds wander about the lowland and up on the bluffs during the day, but generally return to the thickets at night. The conditions favorable for the distribution of this and the preceeding species seem to be an abundance of weed seed, and a thicket in which to roost and fly for protection.

GENERAL OBSERVATIONS.

During the winter small flocks of chickadees usually accompanied by a few White-breasted Nuthatches and Downy Woodpeckers roam about the brushy swamp land. A few Blue Jays are also found here.

BIRDS FOUND AT STATION I. (SWAMP).

1. Peid-billed Grebe. Seen every spring and fall, a few pair breed.
2. Loon. One or two pairs seen on the river every spring and fall.
3. American Merganser. Migrant; individuals seen in spring.
4. Green-winged Teal. Small flocks stop at the bayou in spring and fall to feed.
5. Blue-winged Teal. Small flocks found with the Green-winged.
6. American Bittern. Casual from spring to fall.
7. Least Bittern. Common; breeding in the rushes.
8. Great Blue Heron. Accidental; a few stop here to feed during the spring and summer.

9. Green Heron. I have only seen a few of these birds each year, generally during June.
10. King Rail. Rare; three nests have been found in June among the flags.
11. Virginia Rail. Only a few seen and one nest found.
12. Sora. Common; several nests have been found in the cattails and rushes.
13. Florida Gallinule. Migrant; seen only in spring and fall in limited numbers.
14. American Coot. A few pairs breed n the flags.
15. Amercian Woodcock. Rare migrant.
16. Wilson's Snipe. Uncommon migrant.
17. Yellow Legs. Common migrant.
18. Spotted Sandpiper. Common from spring to fall, probably breeds but no nests have been found.
19. Solitary Sandpiper. Uncommon migrant.
20. Killdeer. Common summer resident; probably breeds.
21. Semipalmated Plover. Rare spring emigrant.
22. Red-winged Blackbird. Abundant summer resident; breeds.
23. Bronzed Grackle. Common migrant. Nests further up the river.
24. White-crowned Sparrow. Rather common migrant.
25. White-throated Sparrow. Very common migrant spring and fall.
26. Tree Sparrow. Abundant winter resident.
27. Slate-colored Junco. Abundant winter resident.
28. Song Sparrow. Abundant summer resident, nests in swamp.
29. Swamp Sparrow. Rather common summer resident.
30. Yellow Warbler. Very common; breeds in shrubby willows.
31. Northern Yellow-throat. Not common; breeds.
32. Catbird. Common summer resident; breeds in shrubby willows.
33. Long-billed Marsh Wren. Common summer resident; breeds in rushes and flags.
34. Chickadee. Common winter resident, a few pair breed in the dead willow stubs.
35. Blue Jay. Sometimes found in the swamp.
36. Cowbird. Common; breeds.
37. Golden-crowned Kinglet. Spring and fall migrant.
38. Ruby-crowned Kinglet. Not uncommon migrant.
39. Rose-breasted Grosbeak. Rather common; breeds.
40. Downy Woodpecker. Sometimes found feeding in shrubby willows. breeds.
41. Yellow-throated Vireo. Common migrant; also breeds in willows.

General Description of Arboreal Willows (Sta. II.).

This station comprises a strip of land about two hundred yards long by forty yards wide lying along the river. The ground is composed mostly of compact till covered with a layer of humus. Large willows, some two to three feet in diameter and sixty or more feet high, cover the entire strip. The shade produced keeps other lower forms from growing so that the ground is for the most part quite open. On one side flows the river, and on the other, separated by a narrow strip of shrubby willows, is a bed of yellow water lilies.

CONDITIONS IN SPRING.

At the opening of this season the ground is partially covered with ice and snow, and the trees of course are bare. About the middle of April the trees begin to leave out and by the first of May are nearly leaved. The low vegetation which covers part of the strip has not started even at this date. Insects abound in the upper branches of the willows and furnish food for myriads of migrating birds. By the first of June all the plants are in full growth and many are in bloom.

CHARACTERISTIC BIRDS.

Zenaidura macroura (Linn.). Mourning dove. The Mourning Dove arrives about the first of March. At this time it does not remain much in the willows, but wanders about the dry meadow land back of the bluffs, returning to the willows at night. Very little food suitable for Mourning Doves exists in this station early in the spring, which accounts for its scarcity here before the breeding season. Waste grain and weed seeds form the principal diet, although some insects are eaten. It begins nesting long before the trees have started to leave out, one set of two fresh eggs being found the 28th of April, 1902. From this time on until the first of June, fresh eggs can be found. The nests are placed on the horizontal limbs, in the crotches and in every suitable place to be found in the large willows. They are constructed of dead stems, twigs and sometimes a few dry leaves and roots. This material is usually picked up beneath the tree where the nest is being built. The food of the adults consists of seeds of ragweed, sunflower, and various other weeds and grasses. At first the young are fed on this food after it has been partially digested by the parent, but before they leave the nest they can eat entire seeds. Waste corn and other grains which remain from the previous year in the fields back of the bluffs are greedily eaten. Only four stomachs have been examined, but their contents represent the characteristic food as determined by field observations. During the nesting season the doves are abundant at this station, but when nesting is over the majority leave and seek the open stubble fields.

Icterus galbula (Linn.). Baltimore Oriole. The first Baltimore Orioles arrive the last of April and begin nest-building by the last of May. The birds as a rule remain in the tops of the tall willows when there is an abundant insect life. It is here on the ends of the swaying branches that they construct their nests. They are composed of gray plant fiber, and fastened on the extreme ends of the topmost branches, often overhanging the river. The nests are thus far beyond the reach of any enemies without wings. The food is entirely insectiverous and procured mainly in the tops of the willows.

OTHER COMMON BIRDS.

During the migration the most abundant birds are the warbiers. Of these the most common are Black and White, Nashville, Yellow, Black-throated Green, and Redstart. Their migration extends from the first to the middle of May. These warblers feed almost entirely in the tops of the willows. The insect food found there accounts for their preference for this region. The Wood Pewee is found commonly in the higher willows.

The Belted Kingfisher uses the dead branches of the willows overhanging the river as vantage posts from which to observe the fish below. In the

height of the migration period large numbers of Ruby-throated Hummingbirds come to feed on the small flying insects found around the willow blossoms. One nest of the Scarlet Tanger was found here. A few nests of the Warbling Vireo are usually built in the lower branches of the smaller willows.

CONDITIONS IN SUMMER.

There is little change from June to the middle of August. Some of the low vegetation has seeded and this furnishes food for a few stray birds, but as a rule the flora remains about the same. The birds have nearly all finished nesting and by the first of July the majority of young are shifting for themselves.

CHARACTERISTIC SUMMER BIRDS.

The Mourning Dove, so plentiful before, is found only in limited numbers after the first of July. As soon as the nesting season is over, it migrates to the dry open fields where seeds are abundant. This is to be expected as its food is known to consist principally of seeds and grain, neither of which are found to any appreciable extent in this habitat. The Baltimore Oriole also leaves toward fall as the insects which before were so plentiful in the tops of the willows have then disappeared. Once in a while a Blue Jay will be seen here, and now and then a Cowbird. A few Phoebes remain throughout the summer. Both the Red-eyed and Warbling Vireos feed about the lower branches. The Kingfisher still keeps watch from the dead branches projecting out over the water. All thru the summer the pensive call, Pee-a-wee, of the Wood Pewee can be heard, even during the heat of the day.

CONDITIONS IN FALL.

As the season advances, the leaves die and drop off, the vegetation under the trees is nearly all dead, and the soil has become dry and hard. By the end of October the conditions are about the same as in early spring, except for the lack of ice and snow.

CHARACTERISTIC FALL BIRDS.

With the return of the migrants the trees are again filled with warblers, the same varieties being observed as in spring with the addition of many immature Blackpolls. The birds do not linger now as they did when passing north, possibly because of the scarcity of food, the tree tops which before were teeming with insects now harboring relatively few. The Mourning Doves still roost in the willows and migrating blackbirds and grackles alight here or stay for the night.

CONDITIONS IN WINTER.

The arboreal willows offer no inducements to birds in winter, the trees are bare, the ground covered with ice and snow except where sheltered by brush or trees, and not enough weed seed to attract even a few sparrows.

CHARACTERISTIC WINTER BIRDS.

Downy Woodpeckers are sometimes found here hunting for hibernating insects and their eggs. Small bands of Chickadees pass through this habitat, but seldom linger long because of the scarcity of food. These two species

with sometimes a few White-breasted Nuthatches are the only birds commonly found here in winter.

BIRDS OF STATION II. (ARBOREAL WILLOWS.)

1. Mourning Dove. Very common, breeds.
2. Belted Kingfisher. Alight here when fishing.
3. Hairy Woodpecker. Rare straggler.
4. Downy Woodpecker. Straggler throughout the year, also breeds.
5. Yellow-bellied Sapsucker. Migrant.
6. Ruby-throated Hummingbird. Migrant; feeds on insects among flowers of the willows.
7. Phoebe. Common migrant; rare summer resident.
8. Wood Pewee. Common summer resident.
9. Yellow-bellied Flycatcher. Rare migrant.
10. Least Flycatcher. Common migrant, spring and fall.
11. Alder Flycatcher. Common migrant.
12. Blue Jay. Throughout the year. A few nest here.
13. Cowbird. Common.
14. Red-winged Blackbird. Roosts here in spring and fall.
15. Baltimore Oriole. Common, nest in tops of willows.
16. Bronzed Grackle. Common migrant.
17. Rose-breasted Grosbeck. Rather common, rarely breeds in this habitat.
18. Scarlet Tanger. Rare; sometimes nests here.
19. Red-eyed Vireo. Common; nests.
20. Philadelphia Vireo. Rare spring migrant.
21. Warbling Vireo. Common; nests.
22. Yellow-throated Vireo. Common migrant.
23. Blue-headed Vireo. Very rare migrant.
24. Black and White Warbler. Common migrant.
25. Nashville Warbler. Rather rare migrant.
26. Tennessee Warbler. Rather rare migrant.
27. Parula Warbler. Rare migrant.
28. Cape May Warbler. Very rare migrant.
29. Yellow Warbler. Very common.
30. Black throated Warbler. Common migrant.
31. Myrtle Warbler. Abundant migrant.
32. Magnolia Warbler. Common migrant.
33. Cerulean Warbler. Not common migrant.
34. Chest-nutsided Warbler. Common migrant.
35. Bay-breasted Warbler. Uncommon migrant.
36. Blackpoll Warbler. Rare spring and common fall migrant.
37. Blackburnian Warbler. Migrant, not common.
38. Black-throated Green Warbler. Common migrant.
39. Palm Warbler. Rather common migrant.
40. Prairie Warbler. Very rare migrant.
41. Oven Bird. Rare summer resident.
42. Water Thrush. Rather rare migrant.
43. Connecticut Warbler. Very rare migrant.
44. Mourning Warbler. Very rare migrant.
45. Wilson's Warbler. Very rare migrant.
46. Canadian Warbler. Quite rare migrant.
47. American Redstart. Common migrant.

48. Catbird. Common summer resident.
49. House Wren. Rare migrant.
50. Winter Wren. Rare migrant.
51. Brown Creeper. Common migrant.
52. White-breasted Nuthatch. Rare migrant.
53. Red-breasted Huthatch. Rather common migrant.
54. Chickadee. Few in summer; common winter resident.
55. Golden-crowned Kinglet. Common migrant.
56. Ruby-crowned Kinglet. Common migrant.
57. Blue-gray Gnatcatcher. Common migrant.
58. Wood Thrush. Rare migrant.
59. Wilson Thrush. Common migrant.
60. Gray-cheeked Thrush. Uncommon migrant.
61. Olive-backed Thrush. Rather common migrant.
62. Hermit Thrush. Common migrant.
63. Robin. Common; nests.
64. Blue Bird. Rare migrant.
65. Rusty Blackbird. Common migrant.
66. Spotted Sandpiper. Common resident in summer.

DESCRIPTION OF THE FOREST (STA. III.)

The forest includes a portion of the flood-plain, the wooded slope leading up on the west side to the cemetery, and the bluffs, extending back to the cultivated fields. This last area includes the cemetery where the conditions are somewhat modified by man.

With the filling in of the marshy lowland by the combined action of vegetation and deposition the conditions become favorable for the dense woods which we now find covering this part of the flood-plain. The first families to appear are the elm, ash, and maple, the white elm (*Ulmus americana*), silver maple (*Acer saccharinum*), swamp maple (*Acer rubrum*), red ash (*Fraxinus pennsylvanica*), black ash (*Fraxinus nigra*), and buttonwood (*Platanus occidentalis*), forming the major portions of the forest. Following closely upon these are the trees characteristic of still drier areas, such as the black walnut (*Juglans nigra*), butter-nut (*Juglans cinerea*) bur oak (*Americus platanoids*) bitter-nut (*Hicoria minima*), blue beech (*Carpinis caroliniana*), and iron wood (*Ostrya virginiana*). As the bluffs are reached the conditions again change. Where the earth is not very porus, which insures considerable soil moisture, several varieties of oak and hickory are found. Among these should be mentioned the shag-bark (*Hicoria ovata*), pig-nut (*Hicoria glabra*), red oak (*Americus rubra*), white oak (*Americus alba*), and black oak (*Americus velutina*). The last two extend up into the dry, sandy bluffs where they constitute the principal trees. Scattered about the cemetery are small groups of evergreen, mostly balsam, but some cedar and ornamental trees. The balsams were native here, but the arbor vitae have been transplanted. The forest of the flood-plain has considerable undergrowth, consisting of low bushes and many herbaceous species such as the fringed houstonia (*Houstonia ciliolata*), pale Indian plantain (*Mesadenia atriplicifolia*), white grass (*Homaloeenchrus virginicus*), and meadow garlic (*Allium canadense*). The undergrowth on the higher ground among the red and black oaks is quite different than that found on the flood-plain, the prevailing species are as follows: round-headed bush clover (*Lespedeza capitata*), common bush clover (*Lespedeza violacea*), blue-stemmed golden-rod (*Solidago

caesia), showy golden-rod (*Solidago speciosa*), field golden-rod (*Solidago nemoralis*), creeping wintergreen (*Gaultheria procumbens*), black huckleberry (*Gaylussacia resinosa*), blue huckleberry (*Vaccinium vacillans*), and pubescent angelica (*Angelica villosa*). The undergrowth occurs chiefly in the open spots and among the ash maples.

CONDITIONS IN SPRING.

Until the middle of April the forest remains about the same as in winter, the trees are bare, the insects have not come out, and general solitude reigns over the place. The only food to be found at this time consists of weed seeds, which are still very plentiful in certain places, and hibernating insects together with insect eggs. The pine cones furnish food for so few birds that they can hardly be considered. At the end of this time, the trees begin to leave out and the underbrush and low plants show signs of life. By the middle of May the trees are green and the other plants are in full growth. Insects now become plentiful and worms, grubs, and other larvae are abundant. Quantities of weed seeds which before were covered by snow are now exposed and furnish food for large numbers of migrating birds, as well as for the summer residents which are just arriving. During April and May there are many severe rain storms, which wash away most of the accumulated humus on the steeper slopes and deposit it on the flood-plain below. These rains occur early enough in the year so that they do not affect the nesting of the ground birds, the only results worthy of notice from the bird stand point are, first the removal of material which if allowed to accumulate would soon support a luxuriant weed growth, and second, the transporting of this material to the denser forest below where it will go to the support of lowland plants instead of seed bearing weeds. In the early part of the season the only protection offered the birds is that of the juniper heath which grows along the bluff in the less shaded areas, and the evergreens scattered about the cemetery.

CHARACTERISTIC SPRING BIRDS.

Cyanocitta cristata (Linn.). Blue Jay. The Blue Jay is a resident throughout the year but is most common during the spring and early summer, later it wanders about over a large territory. In the spring before the insects have appeared they feed almost entirely on seeds from the various weeds scattered about the open forest. Some waste grain is gleaned from nearby stubble fields and on several occasions they were found tearing the balsam cones to pieces for the seeds concealed there. Acorns are also eaten and are often found wedged into crevices in the bark or in crotches of the trees where the Blue Jay has stored them for future use. Upon examination nearly all of these acorns contain large grubs which are probably as much relished by the Jays as the acorns themselves. Until the trees are leaved out these birds roost in the evergreens and spend much of their time there during the day.

Nesting commences the last of April and extends through May and part of June. Maples, willows, and apple trees are the favorite nesting sites. The material is gathered in the vicinity and consists of twigs, leaves, roots, and often rags and paper. The nests are usually placed in horizontal crotches from ten to twenty feet above the ground. The eggs range from three to five in number, the earliest sets being the largest.

Large quantities of insects and grubs are eaten at this time, but the vegetable food still keeps in the lead. The birds seldom show any anxiety when

the nest is approached, the brooding female generally slipping quietly off and gliding away to a safe distance. When the young are hatched the parent birds are very bold, often striking the intruder in the face with their wings. The young are fed exclusively on insects, beetles, small grasshoppers and caterpillars being found in five out of six stomachs examined. The insect food of the adult in addition to this is composed of bugs, flies, and several kinds of larvae. The birds feed quite a little on the ground where they find beetles, grasshoppers and larvae. As the fruits ripen the Blue Jays add these to their diet, but only in small quantities. The males assist in feeding the young, but are usually more shy and will not approach the nest when it is under observation. Only one brood is raised, but if the first nest has been destroyed, another is usually built. The per cent of insects eaten steadily increases toward the end of the season, probably because the abundance of this kind of food and the growing scarcity of weed seeds. In the early spring the Jays are found in flocks of seven or eight which break up with the advent of nesting season, not to reassemble till the following spring.

In summing up the life of the Blue Jay as observed in this habitat, these facts should be stated: first, the food eaten by these birds, consisting of insects and seeds, is very plentiful during the period when the birds are most common; second, the trees found in the forest are the same as those chosen throughout its range as nesting sites, namely maple, willow, and apple; third, adequate protection is furnished by the evergreens during the early spring and by the other trees later in the season.

Melanerpes erythrocephalus. (Linn.). Red-headed Woodpecker. This brightly colored woodpecker arrives the last of March. During the month and a half which elapses before nesting time, it roams about the forest seeking food principally in the larger trees. Only one stomach has been examined from this period. It contained beetles, wood boring larvae and ants. About the middle of April the Red-head selects a dry dead stub, or decayed limb and commences its nest. From four or five days to two weeks are occupied in digging the cavity varying according to the condition of the wood and the depth of the hole. The nest is usually dug about ten feet from the ground when situated in a stub, but may be at any height where a limb is chosen. No lining is used, the six glossy white eggs being deposited on the fine chips left in the bottom of the cavity. Only one nest is occupied, although there may be several suitable cavities in the same stub where other woodpeckers could nest. One of these holes is occupied during the night by the male. By the middle of May the young are hatched and from now on till the young leave the nest the parent birds will be found in the vicinity hunting for ants and other insects. The food taken by one family of nestlings consisted entirely of ants and beetles. As soon as the young leave the nest the old birds lead them to the edge of the woods where flying insects abound. Here they soon learn to take care of themselves and in a surprisingly short time are left to shift for their own living.

Around the nest the parents show considerable anxiety, the brooding bird pecking the hand vigorously when it is introduced into the nest cavity. These birds have sometimes been seen storing the acorns in crevices in the bark in the same manner as that practiced by the Blue Jay. Besides, gathering insects from the trees these woodpeckers often station themselves on some exposed stump or pole and sally forth after winged insects like a kingbird. A little fruit is also eaten, consisting chiefly of wild cherries, choke berries, and ripe apples.

Those particular conditions which seem to be best suited for the Red-

headed Woodpecker are found in the more open forest where dead or decaying stumps and branches offer nesting sites and food at the same time. In the dense, dark woods they are seldom met with.

OTHER COMMON BIRDS.

Vireo olivaceus (Linn.). Red-eyed Vireo. This vireo is quite common in the thick maple woods. It arrives about the first of May when the trees are partially leaved out and insects are plentiful. It is usually found among the branches of maple and oak, preferring the former. The nest is composed of plant fiber, fine strips of bark, grasses and spider webs. The food of adults consists principally of caterpillars, spiders, bugs, small beetles and ants. Two nestlings were taken which had eaten caterpillars, spiders, and beetles.

Asio wilsonianus. (Less). American Long-eared Owl. During March and the first part of April these owls are very common, often three or four being found together in an evergreen. On one occasion a flock of seven were found roosting in a small arbor vitae. During the day they seldom venture out of the protecting evergreens. The Blue Jay is possibly their worst enemy, although it is not able to do them any material injury. When one of these owls is found by a jay an alarm is instantly raised and soon all the birds in the vicinity are there scolding and making a great racket. Not until he retreats to some more secluded spot will he be left in peace. Their food consists of deer and field mice, many pellets picked up under their roosts containing portions of the skull and other bones with the hairs of these mammals.

Spizella socialis (Wils.). Chipping Sparrow. While this sparrow is not confined to the forest it is found there in large numbers especially in the more open spots where there are maple and apple trees. It shows little fear of man and often hops around picking up crumbs as they drop from the hand. The food found in ten stomachs consisted of insects and weed seeds, caterpillars, beetles, grasshoppers and ants, and constituted the major part of the insect food while the seeds of crab-grass (*Polygonum aviculare*), pigeon grass (*Syntherisma sanguinalis*), clover, ragweed (*Ambrosia artemisiaefolia*), chick-weed, and furslane constituted the principal vegetable food. The nests are usually composed of grasses and horse hairs, both of which can be picked up in the vicinity and are built all the way from six to twenty feet above the ground. Maples and apple trees are generally selected, the latter being preferred.

GENERAL OBSERVATIONS.

During the migration several species of warblers pass through the forest the Magnolia Black and White, Myrtle, Black-throated Green, Black-throated Blue, and Redstart being the most common. Downy and Hairy Woodpeckers nest in the decayed limbs of apple, oak and maple trees. Flickers also nest in the old apple trees and are quite common in the adjacent orchard. Kingbirds and Crested Flycatchers both nest here, the former choosing the open forest while the latter inhabits the denser portions. The Wood Pewee is commonly met with in the darker woods where a few nests have been found saddled into a horizontal limb usually about twenty feet from the ground. Scarlet Tangers and Rose-breasted Grosbeaks are generally found in the damp woods on the flood-plain where a few nests of each have been found.

The Hermit and Wilson's Thrushes occur only as migrants. The underbrush along the edge of the forest is their favorite haunt.

CONDITIONS IN SUMMER.

The flora varies very little during the later part of spring, and the early part of summer. Some species of insects are more numerous and most of the fruits are ripe. Weeds have begun to seed, but the majority ripen toward the end of summer. The birds are through nesting and therefore are less restricted in their movements, wandering about the forest and adjacent habitats.

CHARACTERISTIC BIRDS.

Cyanocitta cristata (Linn.). Blue Jay. Now that the nesting season is over these birds devote their time to feeding and flying about. The food remains the same with the addition of a little fruit. Blue berries, wild cherries, choke cherries, and a few raspberries are eaten, but all summed up, they constitute only a small portion of the summer food. The habits of the Jay and the other birds of this habitat change so little from late spring to fall that there remains very little to add to their spring records.

Melanerpes erythrocephalus (Linn.). Red-headed Woodpecker. The Redhead forsakes the denser woods during the summer, choosing the oaks and nearby orchards. He is still one of the most abundant birds of the forest and his loud, rolling call note resounds from every side. This is especially noticeable early in the morning and on cloudy days.

SUPPLEMENTARY NOTES.

At times, Mourning Doves are quite common, but as a rule they prefer the willows along the river. The Marsh Hawk is commonly seen flying over the forest as is also the Sparrow Hawk. Both of these birds feed on the grasshoppers found in the open woods, as shown by two stomachs of the former and four of the latter. The Sparrow Hawk feeds almost exclusively on insects during the summer; few birds and mammals are eaten, however. The Red-eyed and Warbling Vireos are quite common, the maple trees being the favorite feeding ground. In the underbrush a few Oven Birds are sometimes found scratching among the decaying vegetation for worms and insects.

CONDITIONS IN THE FALL.

During August and the first part of September the birds are moulting and remain secluded, only moving around enough to get food. They are rarely heard singing, about the only bird which still keeps up its singing during these dry hot days is the Red-eyed Vireo. With the coming of autumn, with its beautiful colors, the changing of the leaves and ripening of seeds, the birds take on new life. The Blue Jays and Red-headed Woodpeckers are now in lively competition with the Red Squirrels and Chipmunks for the ripened acorns strewn over the ground. These birds seize an acorn firmly in their beaks and force it deftly into some crevice where perhaps several other acorns may already be lying. There are no birds which could really be called characteristic at this season, but the two already mentioned are perhaps the nearest. The fall migration brings many of the warblers to the woods again, the same ones being observed here now as then. Small flocks of Wilson and Hermit Thrushes are found among the underbrush.

Bands of Golden-crowned Kinglets are found searching for the small insects which still remain on the leaves, or which have secreted themselves for the winter under a loose piece of bark. White-breasted and Red-breasted Nuthatches are quite common in the oak forest, where they find abundant insect food in the crevices and cracks of the bark.

CONDITIONS IN WINTER.

In winter the forest offers good protection and considerable food but the bird life is very small. The scattered groups of evergreens furnish excellent protection from both enemies and storms, as well as supplying considerable insect and vegetable food for large numbers of the former hibernate here in winter, while the seeds in the cones are eaten by a number of birds. The ground being high, the snow does not remain long upon it, and even in severe winters there are many sheltered spots where the earth is bare.

CHARACTERISTIC BIRDS.

Junco hyemalis (Linn.). Slate-colored Junco. The Junco or as it is commonly called the snow bird, arrives in October and remains throughout the winter, sometimes not leaving until the middle of April. It is found in nearly every habitat to a certain extent, but occurs in greatest numbers in the forest where it frequents the more open parts, preferring the evergreens to roost in, and as a place of refuge during storms. In habits the Junco closely resembles the Tree Sparrow. When feeding it shows little fear, but at roosting time or when wandering aimlessly about they take alarm at any slight disturbance. The feeding is principally done on the ground in the more open forest. The food consists entirely of weed and grass seeds, ragweed, crab-grass, pigeon grass, and amaranth forming the largest part. When disturbed it utters a metallic chip which has been compared to the sound produced by clicking two marbles together. The birds are seldom met with except in flocks which often number fifty or more. On a whole, the protection offered the Junco by the evergreens seems to be the controlling factor, as the weed seeds eaten are much more abundant in the open meadow than here.

SUPPLEMENTARY NOTES.

The Blue Jay remains here in considerable numbers feeding on the acorns. Some winters, small flocks of Pine Siskins have visited the forest, the clumps of balsams furnishing the required conditions. Downy and Hairy Woodpeckers are found among the oak and apple trees. Sometimes a Great Horned Owl, or the smaller Barred Owl, hunt for mice in the cemetery, and many pellets from these birds are found under the evergreens where they stay during the day.

BIRDS OF STATION III. (FOREST).

1. Ruffed Grouse. Exceedingly rare.
2. Bob White. Very rare resident.
3. Mourning Dove. Common; nests.
4. Sharp-shinned Hawk. Rare winter resident, also migrant.
5. Cooper's Hawk. Very rare summer resident.
6. Marsh Hawk. Common visitor, occasionally breeds.

7. Red-tailed Hawk. Rare resident.
8. Red-shouldered Hawk. Rare resident.
9. Broad-winged Hawk. Rare migrant.
10. Pigeon Hawk. Rare migrant.
11. American Sparrow Hawk. Common summer resident.
12. American Osprey. Rare migrant.
13. American Long-eared Owl. Common resident.
14. Short-eared Owl. Rare summer resident.
15. Barred Owl. Rather common resident.
16. Screech Owl. Common resident.
17. Great Horned Owl. Rare resident.
18. Yellow-billed Cuckoo. Common summer resident; nests.
19. Black-billed Cuckoo. Common summer resident; nests.
20. Belted Kingfisher. Summer visitor.
21. Hairy Woodpecker. Rather common resident.
22. Downy Woodpecker. Common resident.
23. Yellow-bellied Sapsucker. Rather common migrant.
24. Red-headed Woodpecker. Common summer resident; breeds.
25. Red-bellied Woodpecker. Rare migrant.
26. Flicker. Common summer resident. Breeds.
27. Night Hawk. Rather common summer resident.
28. Ruby-throated Hummingbird. Rather common summer resident.
29. Kingbird. Common summer resident.
30. Crested Flycatcher. Rather rare summer resident.
31. Phoebe. Rather rare summer resident.
32. Wood Pewee. Common resident.
33. Blue Jay. Common resident.
34. American Crow. Common migrant; rare summer resident.
35. Cowbird. Common resident.
36. Orchard Oriole. Rare summer resident.
37. Baltimore Oriole. Rather common summer resident.
38. Bronzed Grackle. Common migrant.
39. Purple Finch. Common winter resident.
40. American Crossbill. Rare winter resident.
41. Redpoll. Very rare winter resident.
42. American Goldfinch. Common resident. Found along the borders.
43. Pine Siskin. Quite rare winter resident.
44. Tree Sparrow. Abundant winter resident.
45. Chipping Sparrow. Abundant summer resident; breeds.
46. Slate colored Junco. Common winter resident.
47. Fox Sparrow. Rather common spring migrant.
48. Towhee. Rather common summer resident.
49. Song-Sparrow. Often comes here to feed.
50. Rose-breasted Grosbeak. Common summer resident; breeds.
51. Indigo Bunting. Rather common migrant; a few breed.
52. Scarlet Tanger. Rather common summer resident.
53. Cedar Waxwing. Uncommon resident.
54. Northern Shrike. Rare straggler.
55. Migrant Shrike. Rare summer resident.
56. Red-eyed Vireo. Common summer resident.
57. Warbling Vireo. Common summer resident.
58. Black and White Warbler. Common migrant.
59. Myrtle Warbler. Very common migrant.

60. Magnolia Warbler. Rather common migrant.
61. Cerulean Warbler. Rare migrant.
62. Chestnut-sided Warbler. Common migrant.
63. Blackburnian Warbler. Rather common migrant.
64. Black-throated Green Warbler. Common migrant
65. Black-throated Blue Warbler. Common migrant.
66. Oven Bird. Common summer resident.
67. Redstart. Common migrant.
68. Catbird. Common summer resident.
69. Brown Creeper. Common migrant.
70. White-breasted Nuthatch. Rather common resident.
71. Red-breasted Nuthatch. Common migrant.
72. Chickadee. Common winter resident; a few stay there all summer and breed.
73. Golden-crowned Kinglet. Very common migrant.
74. Ruby-crowned Kinglet. Common migrant.
75. Blue-gray Gnatcatcher. Rather common summer resident.
76. Wood Thrush. Rather rare migrant.
77. Wilson Thrush. Common migrant.
78. Brown Thrasher. Not very common; breeds.
79. Gray-cheeked Thrush. Uncommon migrant.
80. Olive-backed Thrush. Uncommon migrant.
81. Hermit Thrush. Rather common migrant.
82. Robin. Common summer resident.
83. Blue Bird. Quite common summer resident.

DESCRIPTION OF THE OPEN DRY MEADOWS (STA. IV).

These meadows lie back of and extend to the edge of the bluffs where the forest has been cut away, and the land cleared. For the most part they are covered with weeds and grasses, a small cultivated field and a raspberry patch being the only variations from a typical meadow. In the field are raised corn and turnips. A disused sand and gravel pit is located at one side of the meadow, and here a family of Kingfishers have made their home for several years. Several pairs of Bank Swallows have nested in this same bank the last two years. The meadow proper is overgrown with many weeds and grasses, the most common of which are pig-weed (*Chenopodium album*), ragweed (*Ambrosia artemesiaefolia*), thimble berry (*Pauicum capillare*), crab-grass (*Polygonum aviculare*), pigeon grass (*Syntherisma sanguinalis*), chick-weed (*Portulaca oleracea*), dandelion (*Tararacum taxaracum*), June grass (*Poa pratensis*), and Canada golden-rod (*Solidago canadensis*). The ground is high and sandy except for a large hollow lying at the further side where a layer of humus a couple of feet deep covers the gravel. The vegetation here is very rank and is composed mostly of long grasses.

CONDITIONS IN SPRING.

The snow usually leaves the meadows about the first of March. The ground soon becomes soft and where there is little vegetation is quite muddy. Water accumulates in the hollows and retards the growth of the plants there. Weed seed is abundant, and many birds characteristic of other habitats come here to feed on them. By the last of March many of the grasses are green, but the season is quite well advanced before many of the weeds have made much

growth. The cultivated field lies bare most of the spring and the raspberry patch does not furnish any food till summer.

CHARACTERISTIC BIRDS.

Sturnella magna (Linn.). Meadowlark. This bird arrives about the first of March. On their arrival they feed extensively on the seeds of ragweed, pigeon grass and other weeds. As the season advances they confine themselves more and more to the grassy meadow and their food accordingly changes, insects such as grasshoppers, beetles, and various grubs and larvae forming their principal food. The nests are placed in the long thick grass and are very well hidden. They are composed of dead grass and are often domed with a passageway leading out at the side. The young are hatched the last of May or the first of June. Even when the young Meadowlarks are quite well grown they may be seen following the parents about in the meadow grass waiting to be fed.

An interesting habit of these birds and one which is probably the result of the conditions in their habitat, has often been noticed by the writer. A meadowlark when aware of the presence of a person keeps its back turned, concealing the brilliant yellow and black breast and exposing the brownish striped back which closely resembles the dead grass of the meadow. This instinct is carried out even in more exposed positions as on a fence post, the bird seeming to realize that it is less liable to attract attention by its somber colored back than by its brilliantly marked breast.

Spizella pusilla (Wils). Field sparrow. One of the most common birds of the meadow is the Field Sparrow. Arriving with the other sparrows in April, it remains here until October. It is rather shy and seldom allows close observation. The open meadow where the grass is a foot or more in height seems to offer the most favorable conditions, as here it is found in largest numbers. It is sometimes found in patches of weeds and broom sedge. The food of this sparrow during the latter part of spring, consists principally of insects, caterpillars, beetles, small grasshoppers, and a few ants being found in the stomachs examined. During the early spring and after the nesting season the food consisted to a large extent of the seeds of ragweed, chickweed, knot weed, crab-grass and timothy. The nest is placed on the ground amid tall dead grass and weeds, and is composed of grass, rootlets and dead leaves, of plants growing in the vicinity, and is lined with hairs and fine grasses making a compact cup about two inches deep. The bird is rarely flushed directly from the nest, its habit being to glide off through the grass, not rising up until a considerable distance away. However, if the nest is found they will approach quite closely and show their anxiety by frightened chirps.

From the data given here it will be seen that those conditions which induce the Field Sparrow to choose the grassy meadow as its habitat are the abundance of the particular vegetable and insect food which it relishes and good protection both for itself and its nest, together with the materials of which the nest is composed.

OTHER COMMON BIRDS.

During the early part of spring small flocks of Mourning Doves roam over the cultivated field and the weed patches, picking up waste grain and various seeds left by the winter birds. Flickers are often seen in the grassy meadow hopping about searching for ants and grasshoppers. Kingbirds

often choose the tall stems of various weeds as watch towers from which they sally forth over the meadow in quest of flying insects. A few pairs of Bobolinks nest here and feed on the insects found in the long grass. Their nest like the Meadowlarks, is difficult to find, being composed of dead grass with a few leaves. Vesper Sparrows make their home in the dead grass and weed patches, where abundant food, both insect and vegetable, can be found, and where there is also a suitable place for the nests.

CONDITIONS IN SUMMER.

The only notable change taking place during the summer is the ripening of the seeds and fruits. These change the food of several species from a diet largely insectivorous to one largely composed of weed seeds.

CHARACTERISTIC AND COMMON BIRDS.

The characteristic birds remain the same, namely the Meadowlark and Field Sparrow, and since the conditions have only slightly changed since late spring, which was taken up quite fully, little more need be said concerning them. The maturing of the weed seeds causes the Field Sparrow to change from an insect to a vegetable diet. Among the common summer birds the Brown Thrasher should be mentioned. While this bird is seldom found out in the open meadows it is quite common along their border especially where there are brush piles and thickets. Cowbirds are often seen following the cattle, feeding on the insects which are attracted by them. A few Bronzed Grackles come here to feed, especially on the cleared field, grasshoppers being the food sought.

CONDITIONS IN FALL.

In the fall the weed seeds have all ripened and most of the grass is dead, the fruits have been removed or rotted away, and the major portion of the insects have disappeared. The products of the cultivated field have also been harvested, but where the corn was grown considerable waste grain is still left.

FALL BIRDS.

The most abundant birds found here in the fall are the Killdeer, Meadowlark, American Goldfinch, Vesper, Chipping, White-throated and Field Sparrows. The Killdeers and Meadowlarks feed principally on insect food and prefer the short grass or cultivated field, while the Goldfinch and sparrows feed almost exclusively on the weed seeds remaining for the most part in the patches of dead weeds and long grass. The White-throated Sparrow is migrating, only remaining a couple of weeks, but during this time destroys immense quantities of seed. It is one of the few birds that at rare intervals give vent to their nuptial song while on the southward journey.

CONDITIONS IN WINTER.

The ground may or may not be covered with snow, depending on the weather. But even if the snow is a foot or so deep many of the weeds will still have their seedbearing tops above the crust where the birds can get at them. However, the snow seldom gets more than a few inches deep on the higher ground and really plays only a small part in the conditions influ-

encing bird life at this time. Nearly all the seeds eaten by ground birds are very plentiful and are the controlling factor in the distribution of the birds at this time.

CHARACTERISTIC BIRDS.

Octocoris alpestris praticola Hensh. Prairie Horned Lark. This bird is found throughout the winter and feeds extensively on the seeds of amaranth, crabgrass, ragweed and pigweed. The bird is quite tame and when feeding allows a close approach. The depth of snow does not seem to interfere with these birds, for the tall stems of amaranth which constitutes their principal food are seldom covered. During stormy weather they resort to the thick patches of weeds, but when the snow begins to melt off they go into the grassy meadow. Usually flocks of six to twenty-five are found. Late in February most of the Larks disappear, only a few remaining to nest. Unlike most of the winter ground birds, no other birds are found associated with them.

SUPPLEMENTARY NOTES.

Small flocks of Juncoes and Tree Sparrows come out into the meadow to feed on the abundant seeds. Associated with them are often found a few Goldfinches. If disturbed these birds take refuge in the bushes of nearby habitats. In mild winters a few Mourning Doves remain here and feed in the stubble fields.

BIRDS OF STATION IV. (OPEN DRY MEADOWS.)

1. Killdeer. Common in summer and fall; probably breeds.
2. Bob White. Exceedingly rare.
3. Mourning Dove. Common after nesting season to late fall.
4. Short-eared Owl. Very rare; found in long grass.
5. Flicker. Found feeding during spring, summer and fall.
6. Night Hawk. Rather common summer resident.
7. Kingbird. Feeds upon insects in meadow; common.
8. Prairie-Horned Lark. Common winter resident.
9. American Crow. A few found feeding in meadow.
10. Bobolink. Not common; breeds.
11. Cowbird. Found feeding around cattle.
12. Red-winged Blackbird. Large flocks feed here in fall.
13. Meadowlark. Common summer resident; breeds.
14. Bronzed Grackle. Feeds here in spring and fall.
15. American Goldfinch. Abundant in summer; small flocks seen in winter.
16. Vesper Sparrow. Common summer resident; breeds.
17. Lark Sparrow. Rather rare migrant.
18. White-throated sparrow. Common migrant.
19. Tree Sparrow. Common winter resident.
20. Chipping Sparrow. Feeds extensively on weed seeds in fall.
21. Field Sparrow. Quite common summer resident; breeds.
22. Slate-colored Junco. Common winter resident.
23. Song Sparrow. Found in small flocks, feeding on weed seeds, in spring and fall.
24. Towhee. Commonly found in bush along edge of meadow.
25. Oven Bird. Accidental in summer.
26. Catbird. Common; feeds on berries.

27. Brown Thrasher. Common summer resident generally around brush piles; breeds.
28. Tufted Titmouse. Accidental fall visitant.
29. Wilson's Thrush. Rare migrant.
30. Hermit Thrush. Rare migrant.
31. Robin. Common throughout the summer; nests along fences.
32. Blue Bird. Common migant; found along the fences.

GENERAL SUMMARY.

In order to understand the relation between the physical changes, the vegetation, and the bird life of the region, it is necessary to summarize the present conditions, the plant and bird life, and the changes taking place in connection with the processes which are causing them.

Swamp. (*Sta. I.*) The swamp consists of an open bayou and a stretch of flood-plain thus including a sheet of open water, mud flats, a marsh overgrown with reeds, flags, and cattails, and an area of swampy ground covered with shrubby willows.

The birds found here are characteristic of swamps in general, the Coot frequenting the open bays, the Sandpiper the mud flats, while the Marsh Wrens live exclusively in the flags and sedges. The Red-winged Black birds nest in the cattails, and Catbirds together with the Yellow Warbler are found most abundant in the shrubby willows.

Deposition, due both to the depositing of material by the river and the accumulation of material from decaying plants, is the dominant process in this habitat. As the submerged plants die they drop to the bottom and soon form a layer of considerable thickness. The river, especially during the spring floods, adds considerable quantities of earthy material and in a short time the water becomes shallow enough for the deep water sedges. Once these have a good foothold, the land rises rapidly as the roots and stems of the sedge help to catch and hold the material from being washed away. As the water becomes more shallow the other sedges together with the flags and cattails appear. The decay of these plants raises the land still faster and in a comparatively short time clumps of shrubby willows appear. Deposition then extends the area of each plant further out into the river, but the same force is building up the ground back of them thus shortening the area on that side. With this progression in the plant forms, there is one in the bird life complimentary to it, so that as the habitats advance those birds which find in each the conditions best adapted to themselves also advance, but at the same time they must withdraw from the unfavorable conditions which are springing up behind them.

Arboreal Willows. (*Sta. II*). This habitat consists of a strip of till covered with humus and overgrown with large willow trees and very little underbrush. There is little change taking place here, the soil is washed out by the rains and some of it redeposited at different points, and the river during flood times also deposits quantities of material especially along the outer edge. It is evident that the processes of erosion and deposition are about equal. The vegetation is therefore mainly dependent on the topography. The Mourning Dove, Baltimore Oriole, and Wood Pewee, characteristic birds of the large willows bordering streams, are principally found here. The habitat of these birds at present is only increasing to a very slight extent the arboreal willows getting a foothold a little further out in the marsh than formerly.

Forest (*Sta. III*). This station comprises a wooded flood-plain and slope stretching up to the top of the bluffs and extending back to the cultivated fields. The soil on the bluffs is sandy, allowing rapid percolation of the water instead of its running down the slope, thereby greatly diminishing the factor of denudation. The thin layer of humus is thus preserved except on the brink of the steeper bluffs where the weathering is so rapid as to prevent its formation. The process of erosion is dominant on the bluffs, while deposition is the controlling factor on the flood-plain. The erosion tends to reduce the bluffs to base level, and the process of deposition tends to increase the depth of the soil and establish an equilibrium between the bluffs and the flood-plain. The ashes, hickories, elms, and maples characteristic of low woodland clothe this portion, while the red and black oaks occur most plentifully on the high ground. Blue Jays, Red-headed Woodpeckers, Red-eyed Vireos and Wood Pewees, birds which are characteristic of wooded areas, are found here.

Open Dry Meadow. (*Sta. IV.*) These meadows consist of sandy soil overgrown with weeds and grasses. A cultivated field, raspberry batch and a sand pit are included. The dominant process is erosion which is constantly cutting down the higher portions. The thick beds of vegetation materially hinder this work. The characteristic birds are those of open dry meadows in general, namely, the Meadowlark, Field Sparrow, Prairie Horned Lark, Bobolink, Goldfinch and Vesper Sparrow.

CONCLUSION.

It is evident from the data given above that the birds in this region are quite restricted in their choice of habitat, and that the vegetation is the immediate factor which causes this limitation. The birds are to a considerable extent dependent upon it at all seasons for their food and protection, while during the breeding season it determines the distribution of practically all of them, restricting many species to a very small area. But the vegetation is dependent upon the physiographic conditions, and is modified by the processes working upon them, so that the distribution of the birds in a region at any particular time is also influenced by physiographic changes. It is therefore evident that the distribution of the birds in any given area is primarily determined by the geological formations, the physiographic changes taking place, and the resulting biota, i.e., the plant and animal societies characteristic of these conditions.

ANNOTATED LIST.

1. *Podilymbus podiceps,* Pied-billed Grebe. Station I. Rather common migrant; a few breed.
2. *Gavia imber,* Loon. Station I. Rare migrant.
3. *Larus argentatus smithsonianus.* American Herring Gull. Only seen flying over the river in spring and fall.
4. *Merganser americanus,* American Merganser. Sta. I. Migrant; individuals seen in spring.
5. *Nettion carolinensis,* Green-winged Teal. Sta. I. Small flocks stop at the bayou in spring and fall to feed.
6. *Querquedula discors,* Blue-winged Teal. Sta. I. Small flocks found with Green-winged.
7. *Branta canadensis,* Canada Goose. Seen flying over bayou in spring and fall.

8. *Botaurus lentiginosus*, American Bittern. Sta. I. Casual from spring to fall.

9. *Ardetta exilis*, Least Bittern. Sta. I. Common summer resident; breeds in rushes and flags.

10. *Butorides virescens*, Great Blue Heron. Sta. I. Accidental; a few stop to feed during spring and summer.

11. *Ardea virescens*, Green Heron. Sta. I. I have only seen a few of these birds each year, generally in June. A pair or two undoubtedly breed.

12. *Rallus elegaus*, King Rail. Sta. I. Rather rare; a few breed, three nests found.

13. *Rallus virginianus*, Virginia Rail. Sta. I. Rather common; nests in rushes and flags. One nest found.

14. *Porzaua carolina*, Sora. Sta. I. Common; breeds in flags and cattails.

15. *Gallinula galeata*, Florida Gallinula. Sta. I. Migrant; seen only in spring and fall in limited numbers. One pair was found breeding.

16. *Fulicana americana*, American Coot. Sta. I. Common; nests in flags.

17. *Philohela minor*, American Woodcock. Sta. I. Rare migrant.

18. *Gallinago delicata*, Wilson's Snipe. Sta. I. Uncommon migrant.

19. *Tringa minutilla*, Least Sandpiper. Sta. I. Very rare migrant.

20. *Totanus flavipes*, Yellow-legs. Sta. I. Common migrant.

21. *Helodromus solitarius*, Solitary Sandpiper. Sta. I. Rare migrant.

22. *Actitis macularia*, Spotted Sandpiper. Sta. I. Common summer resident; probably breeds.

23. *Oxyechus vociferus*, Killdeer. Sta. I, IV. Common summer resident; probably breeds.

24. *Aegialitis semipalmata*, Semipalmated Plover. Sta. I. Rare migrant.

25. *Colinus virginianus*, Bob-white. Sta. III, IV. Very rare resident.

26. *Bonasa umbellus*, Ruffed Grouse. Sta. III. Exceedingly rare. None have been seen for about three years.

27. *Zenaidura macroura*, Mourning Dove. Sta. II, III, IV. Abundant summer resident; breeds in arboreal willows.

28. *Circus hudsonius*, Marsh Hawk. Sta. III. Common visitor.

29. *Accipiter velox*, Sharp-shinned Hawk. Sta. III. Rare winter resident.

30. *Accipiter cooperii*, Coopers Hawk. Sta. III. Very rare summer resident.

31. *Buteo borealis*, Red-tailed Hawk. Sta. III. Rare.

32. *Buteo lineatus*, Red-shouldered Hawk. Sta. III. Rare.

33. *Buteo platypterus*, Broad-winged Hawk. Sta. III. Rare.

34. *Falco columbarius*, Pigeon Hawk. Sta. III. Rare migrant.

35. *Falco sparverius*, American Sparrow Hawk. Sta. III. Common summer resident.

36. *Paudion haliaetus carolinensis*, American Osprey. Sta. III. Rare migrant.

37. *Asio wilsonianus*, American Long-eared Owl. Sta. III. Common resident; probably breeds.

38. *Asio accipitorinus*, Short-eared Owl. Sta. III, IV. Rare summer resident.

39. *Syrnium varium*, Barred Owl. Sta. III. Rather common resident.

40. *Megascops asio*, Screech Owl. Sta. III. Common resident; probably breeds.

41. *Asio magellanicus virginianus*, Great Horned Owl. Sta. III. Rare.

42. *Coccyzus americanus*, Yellow-bellied Cuckoo. Sta. III. Common summer resident.
43. *Coccyzus erythrophthalmus*, Black-billed Cuckoo. Sta. III. Common summer resident.
44. *Ceryle alcyon*, Belted Kingfisher. Sta. II, III. Rather common summer resident; nests in sand pit and gravel banks.
45. *Dryobates villosus*, Hairy Woodpecker. Sta. II, III. Rather common resident.
46. *Dryobates pubescens medianus*, Downy Woodpecker. Sta. I, II, III. Common resident; breeds.
47. *Sphyrapicus varius*, Yellow-bellied Sapsucker. Sta. II, III. Rather common migrant.
48. *Melanerpes erythrocephalus*, Red-headed Woodpecker. Sta. III. Common summer resident; breeds.
49. *Centurus carolinus*, Red-bellied Woodpecker. Sta. III. Rare migrant.
50. *Colaptes auratus luteus*, Northern Flicker. Sta. III, IV. Common summer resident; breeds.
51. *Chordeiles virginianus*, Nighthawk. Sta. III, IV. Common summer resident.
52. *Chaetura pelagica*, Chimney Swift. Seen in spring and summer feeding over bayou.
53. *Trochilus colubris*, Ruby-throated Hummingbird. Sta. II, III. Not common.
54. *Tyrannus tyrannus*, Kingbird. Sta. III, IV. Common summer resident; breeds.
55. *Myiarchus crinitus*, Crested Flycatcher. Sta. III. Rare summer resident.
56. *Sayornis phoebe*, Phoebe. Sta. II, III. Uncommon summer resident; breeds.
57. *Cautopus virens*, Wood Pewee. Sta. II. III. Rather common summer resident.
58. *Empidonax flaviventris*, Yellow-bellied Flycatcher. Sta. II. Uncommon migrant.
59. *Empidonax virescens*, Green-crested Flycatcher. Sta. I. Found only in shrubbery willows. Rare.
60. *Empidonax traillii alnorum*, Alder Flycatcher. Sta. II. Common spring migrant.
61. *Empidonax minimus*, Least Flycatcher. Sta. II. Common spring migrant; a few seen in the fall.
62. *Otocoris alpestris praticola*, Prairie Horned Lark. Sta. IV. Common winter resident; a few remains to nest.
63. *Cyanoctita cristata*, Blue Jay. Sta. I, II. III. Very common resident; breeds.
64. *Corvus brachyrahynchos*, American Crow. Sta. III, IV. Common migrant; rare summer resident.
65. *Dolichonyx oryziorus*, Bobolink. Sta. IV. Rather common; breeds in meadows.
66. *Molothrus ater*, Cowbird. Sta. I, II, III, IV. Common summer resident.
67. *Agelaius phoeniceus phoeniceus*, Red-winged Blackbird. Sta. I, II, IV. Very common summer resident; breeds.
68. *Sturnella magna*, Meadowlark. Sta. IV. Common summer resident; breeds.

69. *Icterus spurius*, Orchard Oriole. Sta. III. Rare summer resident; breeds.

70. *Icterus galbula*, Baltimore Oriole. Sta. II, III. Common summer resident; breeds in willows.

71. *Euphagus carolinus*, Rusty Blackbird. Sta. II. Common migrant.

72. *Quiscalus quiscula aeneus*. Bronzed Grackle. Sta. I, II, III, IV. Very common; no nests found in this locality.

73. *Carpodacus purpureus*, Purple Finch. Sta. III. Common winter resident.

74. *Loxia curvirostra minor*, American Crossbill. Sta. III. Rare winter resident.

75. *Acanthis linaria*, Redpoll. Sta. III. Very rare winter resident.

76. *Astragaliuus tristis*, American Goldfinch. Sta. III, IV. Common resident; breeds.

77. *Spinus pinus*, Pine Siskin. Sta. III. Quite rare winter resident.

78. *Passerina nivalis*, Snowflake. Sta. IV. Exceedingly rare winter visitant.

79. *Poocaetes gramineus*, Vesper Sparrow. Sta. IV. Common summer resident; nests in meadows.

80. *Passer domesticus*, English Sparrow. Sometimes found at edge of cemetery.

81. *Chondestes grammacus*, Lark Sparrow. Sta. IV. Rare migrant.

82. *Zonotrichia leucophrys*, White-crowned Sparrow. Sta. I. Rather common migrant.

83. *Zonotrichia albicollis*, White-throated Sparrow. Sta. I, IV. Abundant spring and fall migrant.

84. *Spizella monticola*, Tree Sparrow. Sta. I, III, IV. Abundant winter resident.

85. *Spizella socialis*, Chipping Sparrow. Sta. III, IV. Abundant summer resident; breeds.

86. *Spizella pusilla*, Field Sparrow. Sta. IV. Common summer resident; breeds.

87. *Junco hyemalis*, Slate-colored Junco. Sta. I, III, IV. Very common winter resident.

88. *Melospiza cinerea melodia*, Song Sparrow. Sta. I, III, IV. Very common resident; many remain through winter.

89. *Melospiza lincolnii*, Lincoln's Sparrow. Sta. II. In the underbrush at edge of Arboreal willows. Rare migrant.

90. *Melospiza georgiana*, Swamp Sparrow. Sta. I. Rather common summer resident.

91. *Passerella iliaca*, Fox Sparrow. Sta. III. Rather common spring migrant.

92. *Pipilo erythrophthalmus*, Towhee. Sta. III, IV. Common summer resident.

93. *Zamelodia ludoviciana*, Rose-breasted Grosbeak. Sta. I, II, III. Common summer resident; breeds.

94. *Cyanospiza cyanea*, Indigo Bunting. Sta. III. Rather common migrant and summer resident.

95. *Piranga erythromelas*, Scarlet Tanager. Sta. II, III. Not uncommon summer resident; no nest found.

96. *Progue subis*, Purple Martin. Seen flying over bayou in spring and summer.

97. *Petrachelidon lunifrons*, Cliff Swallow. Seen flying over bayou in spring.
98. Hirundo erythrogaster, Barn Swallow. Seen flying over bayou.
99. *Iridoprocne bicolor*, Tree Swallow. Seen flying over bayou. Breeds. Sta. I.
100. *Riparia riparia*, Bank Swallow. Seen flying over bayou in spring. Nests in gravel pit. Sta. IV.
101. *Ampelis cedrorum*, Cedar Waxwing. Sta. III. Uncommon resident.
102. *Lanius borealis*, Northern Shrike. Sta. III. Rare straggler.
103. *Lanius ludovicianus migrans*, Migrant Shrike. Sta. III. Rare summer resident; breeds.
104. *Vireo olivaceus*, Red-eyed Vireo. Sta. II, III. Common summer resident; breeds.
105. *Vireo philadelphicus*, Philadelphia Vireo. Sta. II. Rare migrant.
106. *Vireo gilvus*, Warbling Vireo. Sta. II, III. Common summer resident; breeds.
107. *Vireo flavifrons*, Yellow-throated Vireo. Sta. I, II. Not common migrant.
108. *Vireo solitarius*, Blue-headed Vireo. Sta. II. Very rare migrant.
109. *Muiotilta varia* Black and White Warbler. Sta. II, III. Common migrant.
110. *Helminthophila rubricapilla*, Nashville Warbler. Sta. II. Quite rare migrant.
111. *Helminthophila peregrina*, Tennessee Warbler. Sta. II. Uncommon migrant.
112. *Compsothlypsis americana aisnea*, Northern Parula Warbler. Sta. II. Rare migrant.
113. *Dendroica tigrina*, Cape May Warbler. Sta. II. Very rare migrant.
114. *Dendroica aestiva*, Yellow Warbler. Sta. I, II. Common summer resident; breeds.
115. *Dendroica caerulescens*, Black-throated Blue Warbler. Sta. II, III. Common migrant.
116. *Dendroica coronata*, Myrtle Warbler. Sta. II, III. Very common migrant.
117. *Dendroica maculosa*, Magnolia Warbler. Sta. II, III. Rather common migrant.
118. *Dendroica cerulea*, Cerulean Warbler. Sta. II, III. Rare migrant.
119. *Dendroica pensylvanica* Chestnut-sided Warbler. Sta. II, III. Common migrant.
120. *Dendroica castanea*, Bay-breasted Warbler. Sta. II. Uncommon migrant.
121. *Dendroica striata*, Black-poll Warbler. Sta. II. Rare spring and common fall migrant.
122. *Dendroica blackburniae*, Blackburnian Warbler. Sta. II, III. Rather common migrant.
123. *Dendroica virens*, Black-throated Green Warbler. Sta. II, III. Common migrant.
124. *Dendroica palmarum*, Palm Warbler. Sta. II. Rare migrant.
125. *Dendroica discolor*, Prairie Warbler. Sta. II. Exceedingly rare migrant.
126. *Seiurus aurocapillus*, Oven Bird. Sta. II, III, IV. Common summer resident.

127. *Seiurus noveboracensis,* Water Thrush. Sta. II. Rather rare migrant.

128. *Seiurus motacilla,* Louisiana Water Thrush. Sta. II. Rare migrant.

129. *Geothlypi agilis,* Connecticut Warbler. Sta. II. Very rare migrant.

130. *Geothlypis philadelphia,* Mourning Warbler. Sta. II. Very rare migrant.

131. *Geothlypis trichas brachidactyla,* Northern Yellow-throat. Sta. I. Not common; breeds.

132. *Wilsonia pusilla,* Wilson's Warbler. Sta. II. Rare migrant.

133. *Wilsonia canadensis,* Canadian Warbler. Sta. II. Quite rare migrant.

134. *Setophaga ruticilla,* American Redstart. Sta. II, III. Common migrant.

135. *Galeoscoptes carolinensis,* Catbird. Sta. I, II, III, IV. Common summer resident; breeds.

136. *Taxostoma rufuni,* Brown Thrasher. Sta. III, IV. Not common; breeds.

137. *Troglodyteo aedon,* House Wren. Sta. II. Not common migrant. A few breed in orchard.

138. *Albiorchilus hiemalis,* Winter Wren. Sta. II. Uncommon migrant.

139. *Telmatodyteo palustris,* Long billed Marsh Wren. Sta. Common summer resident; breeds.

140. *Certhia familiaris americanus,* Brown Creeper. Sta. II, III. Common migrant.

141. *Sitta carolinensis,* White-breasted Nuthatch. Sta. II, III. Rather common resident.

142. *Sitta canadensis,* Red-breasted Nuthatch. Sta. II, III. Common migrant.

143. *Baeolophus bicolor,* Tufted Titmouse. Sta. IV. Rare winter visitant.

144. *Parus atricapillus,* Chickadee. Sta. I, II, III. Common winter resident; a few stay through the summer.

145. *Regulus satrapa,* Golden-crowned Kinglet. Sta. I, II, III. Very common migrant.

146. *Regulus calendula,* Ruby-crowned Kinglet. Sta. I, II, III. Common migrant.

147. *Palioptila caerulea,* Blue-gray Gnatcatcher. Sta. II, III. Rather common summer resident.

148. *Hylocichla mustelina,* Wood Thrush. Sta. II, III. Uncommon migrant. A pair occasionally nest here.

149. *Hylocichla fuscescens,* Wilson's Thrush. Sta. II, III, IV. Common migrant.

150. *Hylocichla aliciae,* Gray-cheeked Thrush. Sta. II, III. Rather uncommon migrant.

151. *Hylocichla ustulata swainsonii,* Olive-backed Thrush. Sta. II, III. Common migrant.

152. *Hylocichla guttata pallasii,* Hermit Thrush. Sta. II, III, IV. Common migrant.

153. *Merula migratoria,* American Robin. Sta. II, III, IV. Common summer resident; breeds.

154. *Sialia sialis,* Bluebird. Sta. II, III, IV. Not common summer resident; quite a number seen in the fall. Nests in orchard.

Since writing this paper I have observed the Greater Yellowlegs, Whip-poor-will, Savannah Sparrow and Grasshopper Sparrow. There are also records of the Evening Grosbeak and Bohemian Waxwing being seen at the Bayou.

A CONTRIBUTION TO OUR KNOWLEDGE OF INSECTICIDES.

C. T. McClintock, E. M. Houghton, and H. C. Hamilton.

Having occasion to compare the value of certain coal tar products with other recognized contact insecticides, search was made for literature on the subject, particularly as to how they act on insects and what conditions would make for greatest efficiency, without, however, finding anything conclusive.

Some of the older naturalists notably Reaumur and Swammerdam had experimented with individual insects to determine whether the stoppage of the spiracles was the cause of death, and whether the functions of all the spiracles were the same. The conclusion that they differ, and that death follows the clogging of the posterior spiracles but not of anterior ones has been declared erroneous by Kirby and Spence in their text book, "Introduction to Entomology." Dr. La Hille, chief of the Bureau of Applied Zoology to the Minister of Agriculture of the Republic of Argentine, in his "Contributions to the Study of the Ixodes," claims to have proved by experiment that immersion of the posterior part of the Boophilus Annulatus in an efficient insecticide is all that is necessary; immersion of the head for an equal length of time in the same solution not having any effect. This insect, however, has only two spiracles which are located in the posterior part of the body.

These writers are exceptional either in having made experiments or having recorded them where they would be available. Different living authorities on such subjects profess themselves to be ignorant of the method of action of insecticides or have unproved theories as to how the various contact insecticides might be efficient and as to the proper condition of the oil which forms the base of many of the best insecticides.

American writers on economic entomology have confined themselves to mass action of insecticides, apparently caring little as to the selective action of the material or the comparative values of similar preparations. Finding nothing in the literature which would indicate how an emulsified oil might act on the insect, what different effects one might expect from the use of oils of different chemical and physical properties, the time seems opportune for a somewhat extended statement of the results we have obtained from our experiments.

How does the character of the emulsion effect its insecticidal value? Do the insecticidal and germicidal values of the preparations depend on the same constituents? Is there any relation between those two properties and the toxicity toward higher animals? And, most important of all, can a laboratory test be made to determine the relative values of different insecticides with any degree of accuracy, in other words, can they be standardized?

Since chemical standardization presupposes knowledge of what constituents and what forms of combination are necessary to produce a valuable product, and since one or both of these points are more or less enveloped in uncertainty, the present stage of our knowledge precludes the use of chemical methods or at most, only in part.

The conditions which produce the most efficient contact insecticide have been found to differ for oils even of the same origin. Of those derived from coal tar, two of them which differ in apparently only unimportant characteristics may differ greatly in their effects on insects, quantitatively if not qualitatively.

To standardize such preparations therefore, requires the determining of not how much of a certain constituent there is present, for similar oils may counteract as well as dilute the effect of this ingredient; but to determine whether the proper conditions have been obtained by noting its action on the insects themselves. And as it must be a method allowing of indefinite repetition, the number of variable factors must be reduced to a minimun.

The insect must be detached from its host; it must be possible to limit to a second the time it is exposed to the action of the solution and to remove the protecting film of air which prevents actual contact with the insecticide.

These conditions have been secured by the use of tubes open at both ends, in which the insects may be placed and imprisoned by covering the ends with a porous cloth (India Mull). Then by using a hook which will fasten into the cloth, the tube with the insects may be quickly plunged into the solution. By rapid agitation, the protective air globules which surround the spiracles and prevent the drowning of insects can be removed so that intimate contact with the insecticide results. At the end of the period of time, usually one minute, during which time the insect is submerged, it is quickly removed with the hook and the clinging solution shaken off, the capillary action of the cloth tending to draw off all excessive moisture.

It is then transferred to bibulous paper and covered with a clock glass, which allows sufficient air and easy observation. Different insects vary greatly in the rapidity with which they recover from the action of an insecticide too greatly diluted to be effective, and also in the degree of dilution necessary to kill. Different insecticides are peculiar in the fact that the immediate and ultimate effects on the same kind of insects are so different.

In the course of these experiments numbers of the readily available insects have been used, including house flies, black ants, hog lice, sheep ticks, cattle ticks, dog fleas and bed bugs (Cimex lectularius). Each has its peculiar disadvantage as a test insect, even aside from the natural difficulty of catching it and applying the material. Flies, ants and lice are short lived in captivity, the controls often dying as soon as or before those that were dipped; Southern cattle ticks have not been studied in all their stages of development; the large females under observation being extremely resistant to some very efficient insecticides; sheep ticks have the disadvantage of being very slow to recover from the effects of preparations which stupify but do not kill; fleas are too lively to work with to any advantage; while bed bugs, after one becomes accustomed to the odor, and skillful in allowing no escapes, have some points of decided advantage.

They can be kept in captivity for a considerable period of time, and be almost as resistant as when first captured; they are the most resistant of all the common insects; they recover promptly when the insecticide is too weak to be effective, and lastly, one need not depend on the household pest for supplies. Contrary to the accepted belief that this insect is found to any extent only in human habitations, the true Cimex Lectularius makes its home with, and preys upon, the guinea pig; and an unfailing supply may usually be found in the cracks and crevices of the pens.

One of the difficulties which would naturally suggest itself in the attempt to standardize a series of insecticides by the method outlined is the variation

in the resistances of individual insects. This, however, appears not to be so serious as might be expected, although in every test one must use enough of them so that exceptional cases will not lead to erroneous conclusions.

One peculiar instance of variability noted in the bed bugs and which may therefore be avoided when working for accurate results is that the young, light-colored or translucent insects are usually more resistant than the larger full-fed ones. This is not invariably true but occurs so frequently as to be taken as a general rule.

The rapidity with which bed bugs recover from immersions in dilutions of insecticides too great to be effective makes it possible to arrive at prompt conclusions; while its natural resistance makes it probable that conclusions drawn from results with this as the test insect will hold good for most others. By making one minute the invariable length of time the insect is submerged, the degree of dilution of the different insecticides may be used to determine the comparative efficiencies of such preparations.

The effective working strengths however, may not have the same ratio because of the conditions surrounding the insect when in its natural location; that each case has its peculiar conditions. A sheep's wool, for instance, will hold the material in contact with the insect much longer than can be hoped for when dipping swine.

Having now a method of standardization which yields reasonably accurate results, it is possible to determine for any certain purpose what class of insecticides is most applicable. But the most valuable feature, is the opportunity it offers for working out new insecticides and determining at once what advantages they may possess over others; and also the possibility of determining by further study how insecticides act, so that more intelligent means may be used for developing new preparations or improvements.

Without any definite statement to that effect, the general proposition has been accepted that poisons, germicides, and insecticides belong in the same catagory. But a glance at the accompanying chart and table shows a wide divergence in those values.

A point brought out in the investigation of coal tar oils, and also graphically shown in the chart, is that by proper manipulation one may obtain a product, the value of which is high, either as an insecticide or as a germicide and that the former property may be exceptionally high.

We have confirmed the fact that the insecticidal value of soft soap is very considerable. This might raise the question whether the average coal tar dip on the market, the efficient dilution of which cannot in most cases be greater than 1 in 75, does not owe its efficiency to the soap contained. But more important than that is the question whether an oil is in the more efficient condition, in solution, or emulsified and in the form of globules of varying sizes.

One would think without hesitation that a solution, or the very finest possible emulsion would be the more efficient because of being in the more penetrable form. Results with different oils, however, have not been sufficiently uniform to permit definite conclusions. Further work will be required with a greater range in the oils used and a greater diversity in the conditions to decide this important point. The solution of this question is inseparably connected with the greater one, of how any contact insecticide performs it work.

The coal tar insecticide and coal tar disinfectant mentioned in the list of products compared are made from different parts of the distillate from coal as obtained in the production of coke and gas. These redistilled por-

tions of oil have been separated to give, in the one case, that part having the highest germicidal value and in the other, the one having highest insecticidal value. The former is made so that dilutions of 2%, or greater in water make clear solutions, while the latter contains only sufficient soap to make a satisfactory emulsion; the amount necessary varies with different oils, but approximates a mixture containing 20 to 25%.

An ideal preparation for general purposes would be a mixture of the two, but unfortunately, all experiments to date indicate that such a mixture produces an insecticide no better in value than that of the weaker member; while one would naturally expect it to be lowered only to the extent of the dilution. This would indicate that the presence of certain constituents in an insecticide must be avoided in order to obtain one of the highest efficiency; to be specific, the insecticidal properties appear to be neutralized by the presence of Carbolic Acid, or any member of the phenol series; and the value is lowered to that of the particular phenols which may be present, although they may constitute less than 10% of the whole. An oil containing 8% of phenols and whose greatest insecticidal value is 5 times that of Carbolic Acid may have that value increased to 125 by the removal of the phenols.

This shows that, beyond a certain point, the phenols alone are of very ittle value; so little, in fact, that Carbolic Acid will not kill the test insects in the strongest possible aqueous solution with one minute's immersion. This dilution and time, however, have been taken as the unit for the sake of using a standard the same substance as the unit for each of the three properties —toxicity, germicide and insecticide.

By comparing, in the charts, the insecticidal values of Carbolic Acid in aqueous solution, a solution of soap, and a mixture of the two, one may conclude that whatever insecticidal value Carbolic Acid appears to have when in contact with the insect for one minute is due entirely to the soap, as it alone would have been the more efficient.

The use of a gaseous insecticide has an advantage which is in many cases not possible to obtain with liquids, in particular as a means of eradicating household pests—the bed bug, cockroach, ant, fly, mosquito, and moth. But the diffusibility of gases while being their chief advantage, is a weighty objection to their use, because many rooms and houses are not sufficiently tight to retain the gas. The very poisonous or irritating gases like hydrocyanic acid or sulphur dioxide may be effective while the less poisonous or more diffusible gases never become sufficiently concentrated to accomplish much.

The method adopted for testing gaseous insecticides is as follows: The gas or vapor is generated at the bottom of a loosely covered glass cylinder 4 inches in diameter, and 12 inches high. This is placed in a hood with closely fitting glass doors and with an easily regulated exhaust pipe for removing the vapors at the end of the experiment, also with means for heating, either gas or steam, controlled from the outside. The insects are placed in the same tubes used for dipping and are suspended in the upper end of the cylinder. This is for intimate contact with the almost undiluted vapor. Then two open vessels with insects are placed, one on the floor and one near the top to determine the effect of the more diffused gas or vapor. The great difference between results of action from direct contact and from the more diffused gases is striking, showing that it is a method upon which no reliance can be placed. Bed bugs recovered in nearly every case when exposed to diffused coal gas, formaldehyde, carbon dioxide, sulphur dioxide, camphor vapors and vapors of many volatile oils including coal tar oils, pine oil, oil of

pennyroyal, etc.; when exposed to the direct action of these, however, they rarely recovered, except from Ammonia gas and the vapors of carbon disulphide. Hydrocyanic acid gas is extremely poisonous even when quite diffused; the only objection to it being, the fact that it is equally poisonous to human beings. All insects, however, are not so resistant to the action of vapors and gases.

The chemistry of germicides is on a much better basis than that of insecticides. The chemist and the bacteriologist working together have been able to determine the constituents of coal tar and the conditions necessary to produce any possible germicidal value, while a carbolic acid coefficient has been assigned to most of the well known chemicals; so that in many cases a chemical analysis is sufficient to determine the germicidal value, even of coal tar products, a value which checks up very closely with that determined by a bacteriological test. We have found the B. pyocyaneous, the most satisfactory test organism; the advantages of which are threefold: its high resistance to germicides, its easy growth on beef bouillon or other media, and its characteristic formation of green pigment. These properties make it easy to conclude as to the dilutions which are efficient while its high resistance assures one that any other germ under like conditions will be destroyed in dilutions of the disinfectant much greater than are required for the B. pyocyaneous. There is this advantage to the use of it alone, as the test organism that its carbolic acid coefficient is much smaller than if almost any other germ were used.

In the table and chart, the germicidal value of each agent used is expressed in terms of carbolic acid using B. pyocyaneous as the test organism, but to illustrate the selective action that certain germicidal products may have toward certain organisms, it might be stated that two coal tar oils derived from coal distilled under different conditions, can have the same carbolic acid coefficient based on B. pyocyaneous, while when based on B. typhosus, the value of one is nearly twice as great. These results are not inconsistent but they make the value of any comparative tests of germicides depend on a complete account of the method followed. In fact, so much depends on the minutia of details that an absolute agreement between two bacteriologists, working independently, is not to be expected. The method followed in our experiments is in some of its features, very similar to that adopted by the Royal Commission of London for the standardization of disinfectants.

A 24 hour growth of the B. pyocyaneous in bouillon culture medium, is filtered to break up or exclude clumps of bacteria difficult of penetration. Six drops of this culture containing millions of bacteria are mixed with 5 cc. of a dilution of the germicide. After one minute's contact with this, a subculture is made by removing a loop full of the solution, which, if properly mixed, will contain a proportional number of the bacteria originally introduced. This loop full is planted in a tube containing 5 or 6 cc. of sterile bouillon which is then placed in the incubator for 24 to 72 hours, during which time any organism not destroyed will have multiplied sufficiently to be readily recognized. Subcultures are made in a similar manner after 2, 3, 4 and 5 minutes contact between bacteria and germicide, and changes are made in the dilution of the latter until such a dilution is obtained which will allow growth after two or three minutes contact, but less than five minutes. The degree of dilution which will give this result for each preparation can be used in comparison with that dilution of Carbolic Acid which is equally efficient to obtain what is known as the Carbolic Acid Coefficient—a very satisfactory method of readily showing the relative values of different germicides under

the same conditions. But the widely differing conditions under which germicides must be used, makes any table of comparisons of only limited value.

That there is very little relation between the germicidal and insecticidal values, is most graphically shown in the case of the coal tar products and the mercury salts; and it can readily be seen that no chemical investigation would have revealed the facts brought out by careful insecticidal and germicidal tests. Most important of all, is the fact that these values are so susceptible to conditions not easily recognized by a chemical assay and that, therefore, in many cases, chemical specifications are without value for designating any efficient preparation. To many who are not familiar with the fact that some very important pharmacopoeial preparations admit of no test superior to a biological examination, this may seem a serious drawback. But surely no one will deliberately ignore the only satisfactory means of judging the values of such preparations.

The toxic action of these various products show no greater similarity than that of the other properties. That the toxicity of the phenol series of coal tar derivatives does not increase as the members increase in germicidal value, has long been known. In fact, the toxicity is, in some cases, in inverse order to the disinfecting power.

The value of a germicide or insecticide depends often as much on its negative as its positive virtues; particularly, its lack of injury to the animal or the material with which it comes in contact. To determine toxicity of the various salts, alkaloids, and coal tar derivatives used in these experiments, the following described method was employed.

Guinea pigs were dosed per stomach by means of a catheter passed between the forcibly opened jaws into the oesophagus and varying amounts of solutions of the different drugs, were injected through the catheter by means of a 10 cc. syringe, the end of which fits into the catheter. This uniformity in the size of the dose—10 cc. in each case, makes necessary a great difference in the dilution of the different drugs; the results may, therefore, in some cases, be misleading, because of death from local irritation rather than from absorption of the toxic substance. For that reason, no attempt was made to determine the toxicity of some compounds known to destroy tissue rather than to be strictly poisonous.

In the table will be noticed the surprisingly high toxicity of Potassium Cyanide in solution and Arsenic and their very great difference in insecticidal value, while on the other hand will stand out the striking similarity in toxicity of coal tar derivatives other than Carbolic and Cresylic Acids and their wide variations in other respects. One peculiar effect coal tar preparations have is their being absorbed through the skin of cats. When a cat is dipped in a solution containing compounds of the phenol series, even when the head is not submerged, and the animal is not permitted to lick itself and so swallow some of the solution, death almost invariably follows, unless the animal is within five minutes, thoroughly washed free from all traces of the solution; while, when so washed, recovery has followed in every case noted. Where death has followed the dipping of a cat in a carbolic dip, this has occurred after several days of very evident suffering with every appearance of its being phenol poisoning.

SUMMARY.

1. The work reported in this paper has to do with the contact insecticides only. Those substances which destroy insects when ingested have not been considered.

2. The insecticidal, gremicidal and toxic values (for higher animals) have little or no correlation.

3. It is possible to determine the relative strength or value of insecticides by immersing test insects in definite strengths of the insecticide, and noting the time required to produce death.

4. The common bedbug (*Cimex lectularius*) appears to be the most satisfactory test insect.

5. As yet the mode of action, the way in which the contact insecticides cause the death of the insects, has not been determined.

6. Apparently the fewer the number of spiracles, the smaller their size, and the better they are guarded by hairs or valves, the more resistant is the insect to the contact insecticides.

7. Chemical standardization of this class of insecticides is with our present knowledge impossible. With two substances, having essentially the same chemical composition, the insecticidal values may vary enormously. Even the same substance, prepared with what are apparently unimportant chemical variations, gives widely different insecticidal values.

Detroit Mich., U. S. A.

LIST OF TABLES AND CHARTS.

TABLE I.—TOXICITY.

GUINEA PIGS, 10 cc. FLUID GIVEN PER OS.

	Weight of pig.	Dose per gramme.	Result.
(1) Arsenic—As_2O_3	515 grms.	.00002	dead
	420 "	.00003	"
	305 "	.00004	"
	700 "	.00001	alive
	670 "	.00002	dead
	620 "	.000015	alive
	680 "	.00002	dead*
(2) Alcohol	610 "	.01	dead
	560 "	.015	"
	700 "	.005	alive
	595 "	.007	"
	545 "	.007	"
	680 "	.008	
	560 "	.009	dead*
(3) Carbolic Acid with water only	580 "	.0006	alive
	635 "	.0008	"
	685 "	.0010	dead
	590 "	.0008	"
	530 "	.0010	"
	700 "	.0005	alive
	490 "	.0006	"
	570 "	.0007	"
	575 "	.0008	dead*
	515 "	.0008	"
(4) Carbolic Acid and soap equal parts	480 "	.0012	alive
	520 "	.0014	"
	390 "	.0016	dead
	605 "	.0018	"
	645 "	.0012	alive
	395 "	.0014	"
	490 "	.0015	dead
	650 "	.0014	alive
	520 "	.0015	"
	630 "	.0016	dead*
(5) Coal Tar Disinfectant	815 "	.002	alive
	655 "	.004	dead
	735 "	.006	"
	555 "	.003	"
	610 "	.004	"
	710 "	.001	alive
	640 "	.002	"
	665 "	.003	dead
	700 "	.002	alive
(6) Coal Tar Insecticide	525 "	.002	dead
	755 "	.004	alive
	440 "	.006	dead
	595 "	.008	"
	585 "	.002	alive
	585 "	.004	"
	700 "	.004	dead
	780 "	.003	alive
	590 "	.004	dead*
(7) Cresylic Acid and Soap equal parts	800 "	.002	dead
	600 "	.003	"
	650 "	.004	"
	715 "	.001	alive
	610 "	.0015	"
	545 "	.002	dead
	680 "	.002	alive
	690 "	.002	dead*
	790 "	.003	"

GUINEA PIGS, 10 cc FLUID GIVEN PER OS.—Concluded.

	Weight of pig.	Dose per gramme.	Result.
(8) Morphine sulphate	515 grms.	.00075	dead
	780 "	.00150	"
	685 "	.0004	alive
	815 "	.0006	dead*
(9) Nicotine	515 "	.00001	alive
	610 "	.000015	"
	765 "	.00002	dead*
	645 "	.00003	"
	765 "	.000015	"
	615 "	.00002	"
	725 "	.000015	"
(10) Potassium Cyanide	540 "	.0001	dead
	510 "	.0002	"
	800 "	.00005	"
	430 "	.00003	"
	570 "	.000015	" *
	585 "	.000015	"
	625 "	.00001	alive
	585 "	.00001	"
(11) Mercuric Chloride	354 "	.00005	dead
	404 "	.00006	"
	375 "	.00003	alive
	262 "	.00003	"
	300 "	.00004	dead*
	411 "	.00004	"
(12) Mercuric Iodide	340 "	.00002	alive
	430 "	.00003	"
	335 "	.00003	"
	327 "	.00004	dead*
(13) Linseed Oil Soap	560 "	.001	alive
	640 "	.002	"
	395 "	.005	dead
	640 "	.002	alive
	655 "	.003	"
	670 "	.004	"
	720 "	.005	dead*

*Minimum fatal dose.

TABLE II.—GERMICIDAL VALUES.

COMPARATIVE VALUE BASED ON RESISTANCE OF B. PYOCYANEUS TO VARIOUS DILUTIONS.

	Dilution.	Time in minutes and results.				
		1	2	3	4	5
(1) Arsenic	1:70	+	–	–	–	–
(As_2O_3) with soap	1:100	+	+	+	+	+
(2) Alcohol	1:4	+	+	+	+	+
	1:3	+	+	+	+	+
	1:2½	+	+	+	–	–
	1:2	–	–	–	–	–
(3) Carbolic Acid Merck with water only	1:150	+	+	+	+	+
	1:100	+	–	–	–	–
	1:75	–	–	–	–	–
(4) Carbolic Acid and Soap equal parts	1:100	+	+	+	+	+
	1:75	+	+	–	–	–
	1:50	–	–	–	–	–
(5) Coal Tar Disinfectant	1:600	+	+	+	–	–
	1:500	+	–	–	–	–
	1:400	–	–	–	–	–
(6) Coal Tar Insecticides	1:100	+	+	+	+	–
	1:50	–	–	–	–	–
(7) Cresylic Acid and Soap equal parts	1:300	+	+	+	+	+
	1:200	+	–	–	–	–
	1:150	–	–	–	–	–
(8) Morphine Sulphate	1:100	+	+	+	+	+
	1:50	+	+	+	+	+
(9) Nicotine	1:10	+	+	+	+	–
(10) Potassium Cyanide	1:100	+	+	+	+	+
	1:50	+	+	+	+	+
(11) Mercuric Chloride	1:80000	+	+	+	+	+
	1:70000	+	+	+	+	–
	1:60000	+	+	+	+	–
	1:50000	+	+	+	+	–
	1:40000	+	+	+	–	–
	1:30000	+	+	–	–	–
	1:20000	+	–	–	–	–
	1:10000	–	–	–	–	–
(12) Mercuric Iodide in the form of Germicidal Discs	1:100000	+	–	–	–	–
	1:80000	+	–	–	–	–
	1:60000	–	–	–	–	–
(13) Formaldehyde 40 %	1:50	+	+	+	+	+
	1:33	+	+	+	+	–
	1:25	+	+	+	–	–
	1:20	+	+	+	–	–
	1:16	+	–	–	–	–
(14) Linseed Oil Soap	1:100	+	+	+	+	+
	1:200	+	+	+	+	+

TABLE III.—INSECTICIDAL VALUES.

EFFECTS ON CIMEX LECTULARIUS (BED BUGS), WHEN DIPPED IN VARIOUS DILUTIONS.

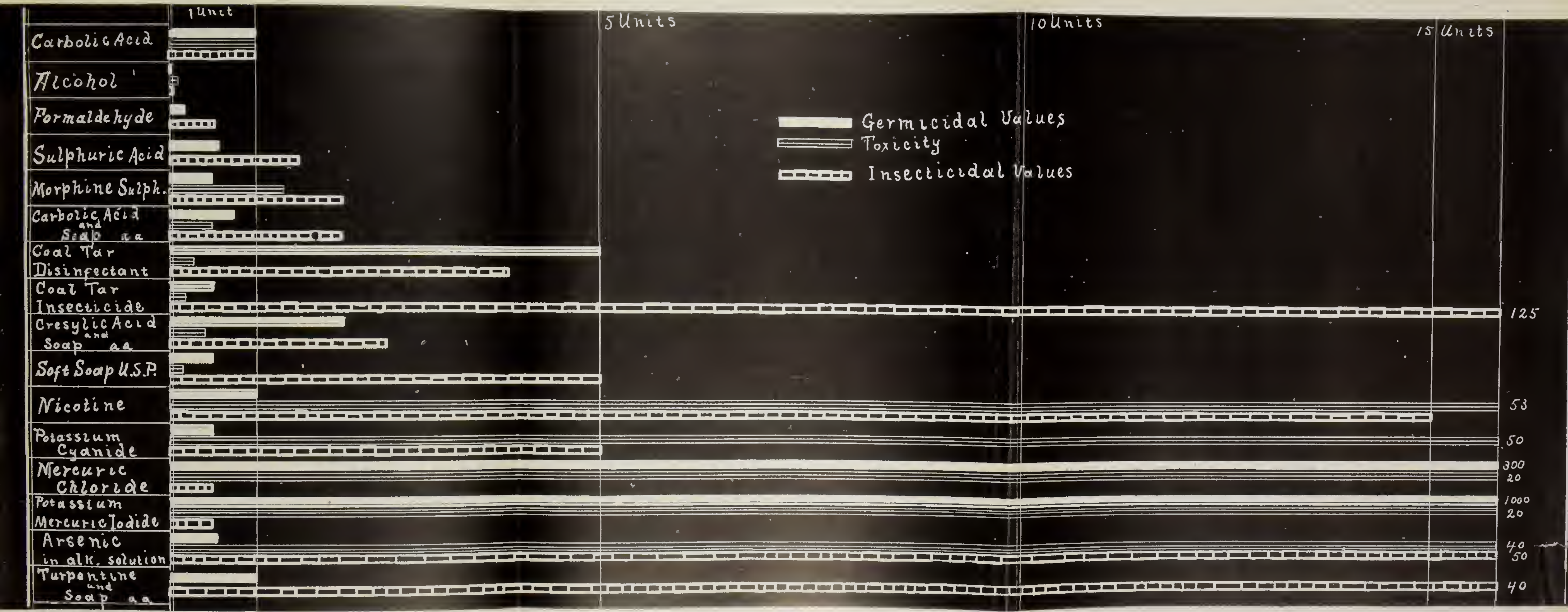
	Dilution.	Time.	Number of insects dipped.	Result.
(1) Arsenic in alkaline solution	1:1000	1 minute	6	dead
	1:1400	1 "	4	alive
(2) Alcohol	50 %	1 minute	2	alive
	70 %	1 "	2	"
	80 %	1 "	4	"
	94 %	1 "	6	dead
(3) Carbolic Acid in aqueous solution	1:50	1 minute	4	alive
	1:20	1 "	4	"
	1:20	2 minutes	2	dead
(4) Carbolic Acid and Soap 1-1	1:100	1 minute	2	alive
	1:50	1 "	4	"
	1:33	1 "	4	dead
(5) Coal Tar Disinfectant	1:75	1 minute	4	dead
	1:100	1 "	5	alive
(6) Coal Tar Insecticide	1:500	1 minute	4	dead
	1:1000	1 "	8	"
	1:1500	1 "	12	"
	1:2000	1 "	4	"
	1:2500	1 "	10	alive
(7) Cresylic Acid and Soap	1:100	1 minute	4	alive
	1:50	1 "	2	"
	1:50	1 "	4	dead
(8) Morphine Sulphate	1:50	1 minute	4	alive
	1:100	1 "	4	"
(9) Nicotine 10 %	1:20	1 minute	3	dead
	1:30	1 "	6	alive
(10) Potassium Cyanide	1:100	1 minute	6	dead
	1:200	1 "	4	alive
	1:300	1 "	2	"
(11) Mercuric Chloride	1:15	1 minute	4	alive
	1:30	1 "	6	"
	1:50	1 "	4	"
(12) Mercuric Iodide in the form of Germicidal Discs	1:15	1 minute	4	dead
	1:30	1 "	4	alive
	1:50	1 "	4	"
(13) Linseed Oil Soap	1:200	1 minute	8	alive
	1:100	1 "	10	dead
	1:50	1 "	4	"
(14) Formaldehyde 40 %	1:5	1 minute	4	dead
	1:10	1 "	4	alive
(15) Turpentine Emulsion	1:750	1 minute	8	dead
	1:1000	1 "	8	alive

TABLE IV.—SUMMARY OF TABLES I, II AND III.

	Amount per body weight.	Effective Dilution.	
	Toxicity.	Germicidal.	Insecticidal.
Arsenic, Alk. Sol.	1–50000	1–70	1–1000
Alcohol	1–110	1–2½	100 %
Carbolic Acid Aq. Sol.	1–1250	1–100	1–20 +
Carbolic Acid and Soap a. a.	1–625	1–75	1–33
Coal Tar Disinfectant	1–333	1–500	1–75
Coal Tar Insecticide	1–250	1–50	1–2500
Cresylic Acid and Soap a. a.	1–500	1–200	1–50
Morphine Sulphate	1–1660	1–50 +	1–50 +
Nicotine	1–66670	1–100	1–300
Potassium Cyanide	1–100000	1–50 –	1–100
Mercuric Chloride C. P.	1–25000	1–30000	1–15
Mercuric Iodide (discs.)	1–25000	1–100000	1–15
Linseed Oil Soap	1–200	1–50	1–100
Formaldehyde 40 %	....	1–16	1–20
Sodium Hydroxide	....	1–50	1–33
Sulphuric Acid	....	1–50	1–33
Turpentine Soap	....	1–100	1–750

TABLE V.—COEFFICIENTS.

	Toxicity.	Germicidal.	Insecticidal.
Arsenic	40.	.7	50.
Alcohol	.09	.025	.05
Carbolic Acid Aq. Sol.	1.	1.	1.
Carbolic Acid Soap	.5	.75	2.
Coal Tar Disinfectant	.27	5.	4.
Coal Tar Insecticide	.2	.5	125.
Cresylic Acid and Soap	.4	2.	2.5
Morphine Sulphate	1.33	.5	2. –
Nicotine	53.	1.	15. + –
Potassium Cyanide	83.	.5 –	5.
Mercuric Chloride C. P.	20.	300.	.5 – +
Mercuric Iodide (discs.)	20.	1000.	.5 +
Linseed Oil Soap	.16	.5 –	5.
Formaldehyde	....	.16	.4
Sulphuric Acid	....	5.	15. + –
Turpentine Soap	....	1.	40.



In this series we have used for comparison some of the alkaloids, acids, salts and organic compounds and mixtures which are well known for one or more of the properties under discussion.

The chart illustrates, more graphically than can be shown by figures, how widely these substances differ among themselves, how great the difference in intensity is between the properties of one substance, and what may be accomplished by a mixture of two of them.

Comparing Mercury and Arsenic compounds, both have high toxicities to vertebrates but the former have a selective toxicity toward bacteria or vegetable life, and the latter toward the lower animal life or Arthropoda. This same selective action is seen in the case of the two alkaloids, Nicotine and Morphine. Nicotine is toxic toward animal life but not vegetable. Morphine is not particularly toxic in any respect to the lower animal or vegetable life.

Comparing the values of Carbolic Acid, Cresylic Acid and Coal Tar Disinfectant, all of which are made soluble by mixture with soap; they form an ascending series in their germicidal and insecticidal actions, while the reverse is true of their toxicity toward vertebrates.

Coal Tar Insecticide, having the same origin as the others and the same toxicity toward vertebrates as that of the Disinfectant, shows a remarkably selective action in its toxicity toward insects.

These cases serve to point out a few of the drugs which have decidedly selective action toward certain organisms.

IS TOXICITY A FACTOR IN SOIL PROBLEMS?

A. Dachnowski.

[Abstract.]

Various attempts have been made to account for the physiological dryness of bog habitats. The study here reported in part, and of which a more extended account will appear in the Botanical Gazette, may be summarized as follows:—

(1.) Osmotic pressure and acidity determinations of bog water from a bog island in a lake near Columbus, Ohio, reveal conditions similar to those found in Michigan bogs.

(2.) The bog island under consideration consists of peat forty feet in depth. Its surface vegetation has largely northern bog forms and presents two distinct zones. The bog island is virtually a water culture on a large scale. A series of cultivated plants when grown on the bog, show very marked dwarfing and various xerophilous characters.

(3.) A series of experiments in the form of bog water cultures variously treated gave the following transpiration data:—

PERCENTAGE INCREASE IN TRANSPIRATION.

Culture solution.	Wheat.	Corn.	Shaseolus mull.	Vicia faba.	Elm.	Buckeye.	Cowpea.	Oats.	Tradescantia.
I. Central zone:									
1. Bog soil extract*	0.	0.	0.	0.	0.	....	....	....	0.
2. Bog water untreated	19.	16.	113.	22.	68.	0.	0.	....	9.8
3. Bog water aerated	55.	27.	201.	....	....	1.3	20.	....	3.4
4. Bog water neutralized	209.	91.	....	100.	....	....	....	....	8.6
5. Bog water filtered	245.	52.	225.	215.	94	38.8	42.	....	24.7
6. Bog plant-water	54.	22.	184.	....	....	....	....	....	....
II. Maple-alder zone:									
1. Bog soil extract*	0.	0.	0.	....	....	....	....	0.	....
2. Bog water untreated	38.	65.	287.	....	....	....	....	90.	....
3. Bog water aerated	164.	71.	....	....	....	....	....	44.	....
4. Bog water neutral	298.	136.	335.	....	....	....	....	148.	....
5. Bog water filtered	256.	76.	....	....	....	....	....	....	....
6. Bog plant water	11.	40.	178.	....	....	....	....	113.	....

*4 grs. of bog soil extract and 400 cc. distilled water.

(4.) The corresponding differences in form and general appearance of some of the plants are illustrated in the accompanying plates.

(5.) The plants grown in the solutions treated with $CaCo_3$ and carbon black show not only accelerated growth and an increase in transpiration, but also an increase in dry weight. The increase in dry matter produced varied from 20% to 50% and more.

(6.) That the response to toxic bodies when present in small amounts may lead to acceleration of growth is also evident in connection with a biometric study on the annual wood-increment in Acer rubrum.

(7). The variety of material cited seems to offer sufficient proof that
(a) toxicity is a factor in certain soil problems;
(b) the inhibiting factors of bog conditions are in part due to the presence of injurious, toxic, water-soluble substances—reactions of the plants themselves;
(c) these substances are formed in the absence of O_2 and probably retard oxidation in the tissues as well as transpiration, thus causing stunting and even death;
(d) such toxicity can be corrected by various methods;
(e) an undrained peat substration must therefore necessarily cause a different succession of plants than a drained habitat.

Botanical Laboratory, Ohio State University.

EXPLANATION OF PLATES.

Half-liter jars of the Mason pattern were used, and prepared in the conventional way. The seeds were germinated in sawdust. Transplanting was done when the plants had attained a height of 5-6 cm. The culture media used were prepared as follows:

Solution 1 was made by taking quantities of the subsoil a foot below the surface vegetation and drying it in an oven at a temperature varying between 52° and 60°C. One gram of this was mixed with 100 cc. of distilled water.

Solution 2 was bog water untreated.

Solution 3 is bog water aerated daily by means of a rubber bulb.

Solution 4 was prepared by mixing into the bog water dry calcium carbonate and then filtering off the solution.

Solution 5 was treated by shaking the bog water with carbon (lampblack), and then filtering off the solution.

Solution 6 was obtained from a set of representative bog plants. These were grown in distilled water, in battery jars and this water was then used as a culture medium.

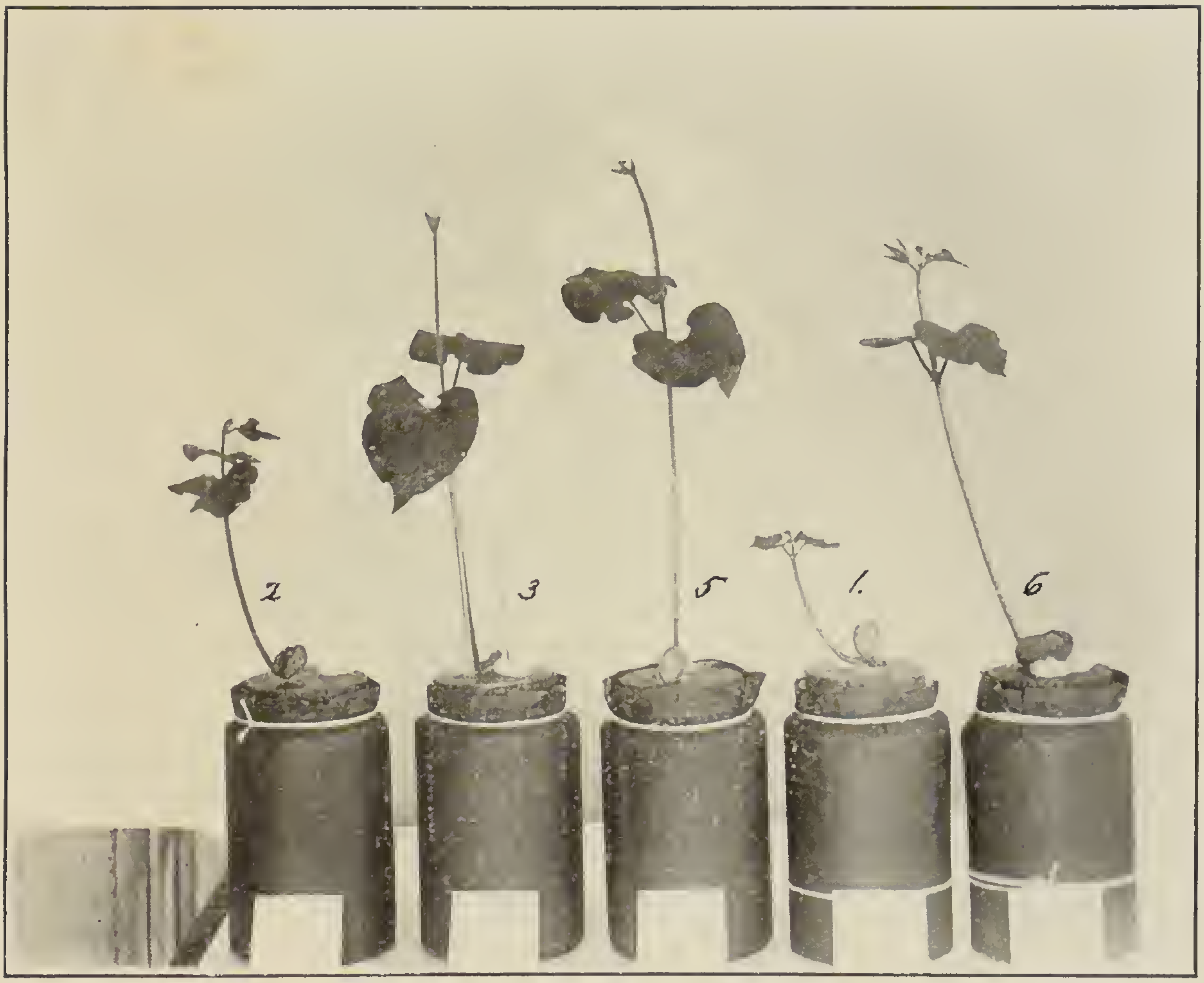


PLATE 1. PHASEOLUS.

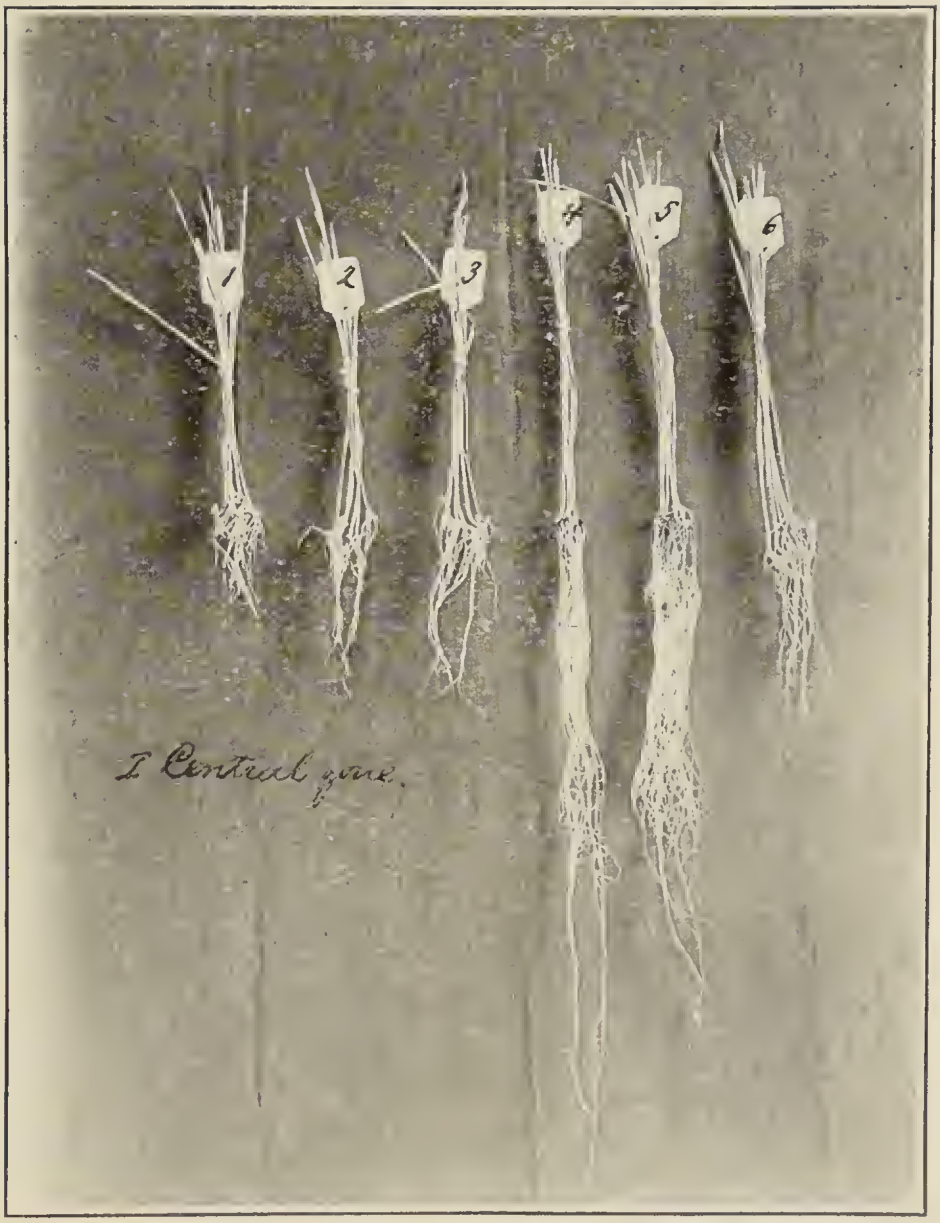


PLATE 2. WHEAT. CENTRAL ZONE.

PLATE 3. WHEAT. MAPLE-ALDER ZONE.

PLATE 4. CORN. CENTRAL ZONE.

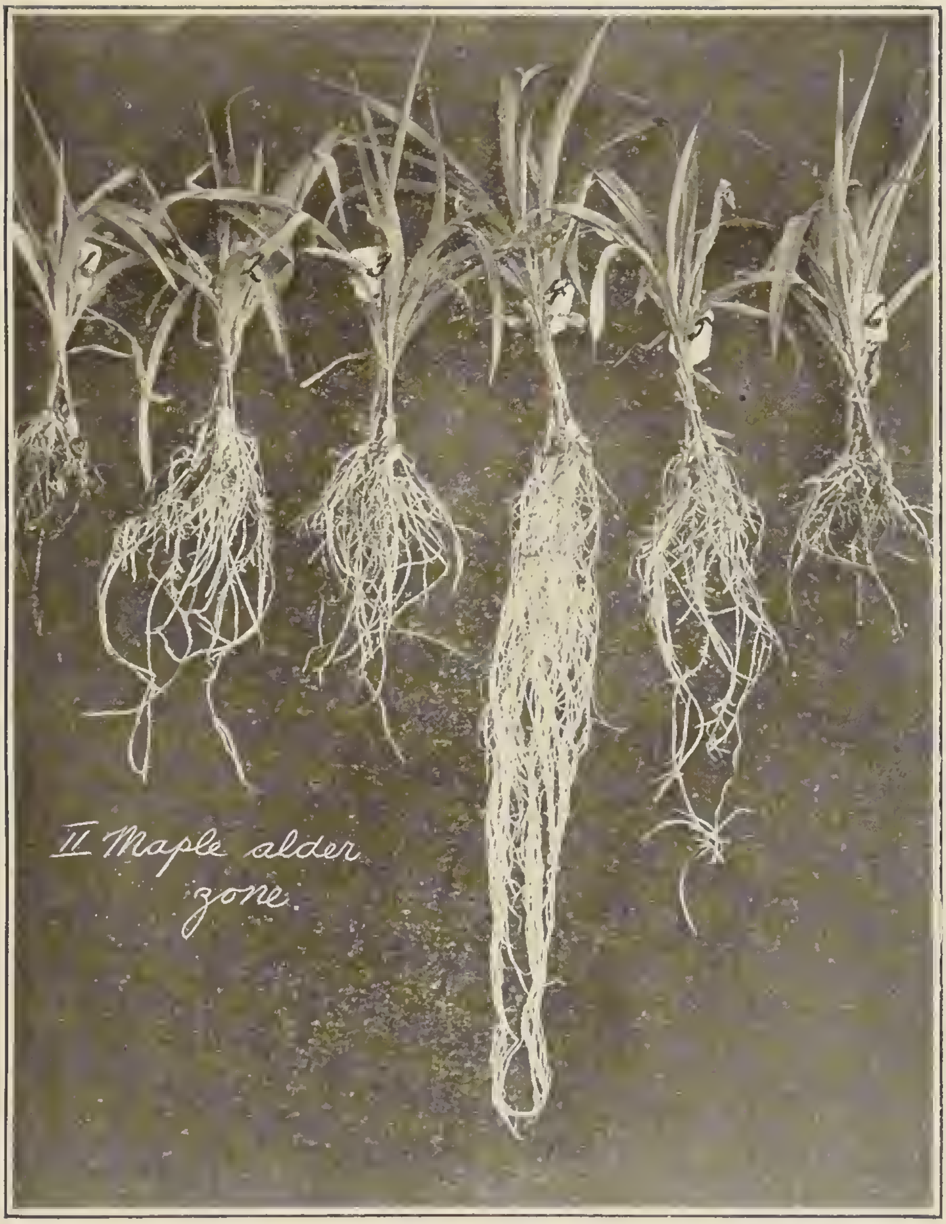


PLATE 5. CORN. MAPLE-ALDER ZONE.

PAPERS PUBLISHED ELSEWHERE AND NOT APPEARING IN THIS REPORT.

Blain, Alexander W., Jr., Urticaria following the second administration of diphtheria anti-toxin, Medical Record, Vol. 73:—June 6, 1908.

Caldwell, Otis W., The just claims of biology in the curriculum of secondary schools, Proceedings of the Michigan Schoolmasters' Club, 1908.

Case, E. C., Discovery of vertebrate fossils from the vicinity of Pittsburgh, Penn., Ann. Carnegie Museum, Vol. IV., Nos. III. and IV., p. 234, 1908.

Glaser, Otto C., A statistical study of Mitosis and Amitosis in an embryonic tissue, Biological Bulletin, Vol. XIV., No. 4, 1908.

Hobbs, W. H., A deduction from the study of bridges which have been disturbed by earthquakes, Jour. of Geology.

Models for the practical solution of problems in structural geology, School Science and Mathematics.

Kraus, E. H., Interpretation of the chemical composition of the mineral Benitoite, Science, n. s., Vol. 27, pp. 710-711, 1908.

Lane, Alfred C., The decomposition of a boulder in the Calumet and Hecla conglomerate, Economic Geology, Vol. III, No. 6, 1908.

Rahn, Otto, Bakteriologische Unteruschungen ueber das Trocknen des Bodens, Centr. f. Bakt., II. Abt., Bd. XX., p. 38, 1907.

Reighard, Jacob, An experimental field study of color discrimination, association and memory in the Gray Snapper and of warning color in coral reef fishes, Carnegie Institution of Washington,—"Contributions from the Marine Biological Laboratory at Tortugas, Fla."

The photography of aquatic animals in their natural environment, U. S. Bureau of Fisheries, Bulletin No. —, 1908.

Ruthven, Alexander G., The Faunal affinities of the prairie region of Central North America, The American Naturalist, Vol. XLII., No. 498, p. 388, 1908.

Sayer, Wm. S., The development of certain milk bacteria at a low temperature, Technical Bulletin No. 1, Mich. Agr. Exp. Sta. (Sayer, Rahn and Farrand), and Annual Report of the Mich. Agr. Exp. Sta., XXI., 1908.

Vaughan, V. C., and Wheeler, S. M., The effect of egg white and its split products on animals, Jour. of Inf. Dis., Vol. 4, No. 3, p. 476, 1907.

Walker, Bryant, Illustrated Catalogue of the Mollusca of Michigan, Part II.

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